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# SCS Toolbox Documentation

SCS

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## INSTALLATION

### 1.1 Recommended: Proposal Environment setup

The proposal specific environment is installed by launching in a shell terminal on Maxwell:

```
module load exfel exfel-python
scs-activate-toolbox-kernel --proposal 2780
```

where in this example 2780 is the proposal number. After this and refreshing the browser, a new kernel named SCS Toolbox (p002780) is available and should be used to run jupyter notebooks on the Maxwell Jupyter hub.

### 1.2 Figures setup: enabling matplotlib constrained layout

To get the best looking figures generated by the SCS Toolbox, you need to enable the experimental `constrained_layout` solver in matplotlib. This is done in jupyter notebook with adding at the start the following lines:

```
import matplotlib.pyplot as plt
plt.rcParams['figure.constrained_layout.use'] = True
```

### 1.3 Alternative: Manual ToolBox Installation

The ToolBox may be installed in any environment. However, it depends on the `extra_data` and the `euxfel_bunch_pattern` package, which are no official third party python modules. Within environments where the latter are not present, they need to be installed by hand.

In most cases, you will want to install it in the `exfel_python` environment which is the one corresponding to the `xfel` kernel on max-jhub.

To do so, first activate that environment:

```
module load exfel exfel-python
```

Then, check that the `scs_toolbox` is not already installed:

```
pip show toolbox_scs
```

If the toolbox has been installed in your home directory previously, everything is set up. If you need to upgrade the toolbox to a more recent version, you have to either uninstall the current version:

```
pip uninstall toolbox_scs
```

or if it was installed in development mode, go in the toolbox directory and pull the last commits from git:

```
cd #toolbox top folder  
git pull
```

Otherwise it needs to be installed (only once). In that you first need to clone the toolbox somewhere (in your home directory for example) and install the package. Here the `-e` flag install the package in development mode, which means no files are copied but only linked such that any changes made to the toolbox files will have effect:

```
cd ~  
git clone https://git.xfel.eu/SCS/ToolBox.git  
cd ~/ToolBox  
pip install --user -e ".[maxwell]"
```

## TRANSFERRING DATA

The DAQ system save data on the online cluster. To analyze data on the Maxwell offline cluster, they need to be transferred there. This is achieved by login at:

<https://in.xfel.eu/metadata>

and then navigating to the proposal, then to the Runs tab from where runs can be transferred to the offline cluster by marking them as Good in the Data Assessment. Depending on the amount of data in the run, this can take a while.

European XFEL myMDC

HOME MY TOKENS MY ACCOUNT LOGOUT

### Proposal no. 002937

Back Edit Runs Beamtime status ▾

General Public Information Runs Team Repositories **Beta!** Calibration Constants History

#### Proposal Runs

Automatically assess new runs (after being closed by DAQ) as: **Good (migrate data to Maxwell)** Off

Automatically start run calibration after migration: **No**

Run Number (alias)	Run type	Sample Name	Start date	Run status	Data Assessment	Calibration	Run Comment	Edit
0709	Test DAQ	NA	2021-09-01 22:54:10 +0200	Closed	Good	<input type="checkbox"/>		
0708	Test DAQ	NA	2021-09-01 15:45:51 +0200	Closed	Good	<input type="checkbox"/>		
0707	Test DAQ	NA	2021-09-01 13:51:21 +0200	Closed	Good	<input type="checkbox"/>		
0706	Test DAQ	NA	2021-09-01 12:41:52 +0200	Closed	Good	<input type="checkbox"/>		





## PROCESSING DATA

On the Maxwell Jupyter hub:

<https://max-jhub.desy.de>

notebooks can be executed using the corresponding Proposal Environment kernel or the xfel kernel if the toolbox was manually installed. For quick startup, example notebooks (.ipynb files) can be directly downloaded from the *How to's* section by clicking on the `View page source`.

### 3.1 How to's

#### 3.1.1 Loading run data

- load run and data.
- load data in memory.

#### 3.1.2 Reading the bunch pattern

- bunch pattern decoding.

#### 3.1.3 Extracting peaks from digitizers

- How to extract peaks from digitizer traces.

#### 3.1.4 Determining the FEL or OL beam size and the fluence

- Knife-edge scan and fluence calculation.

### 3.1.5 Finding time overlap by transient reflectivity

Transient reflectivity of the optical laser measured on a large bandgap material pumped by the FEL is often used at SCS to find the time overlap between the two beams. The example notebook

- Transient reflectivity measurement

shows how to analyze such data, including correcting the delay by the bunch arrival monitor (BAM).

### 3.1.6 DSSC

#### DSSC data binning

In scattering experiment one typically wants to bin DSSC image data versus time delay between pump and probe or versus photon energy. After this first data reduction steps, one can do azimuthal integration on a much smaller amount of data.

The DSSC data binning procedure is based on the notebook Dask DSSC module binning. It performs DSSC data binning against a coordinate specified by *xaxis* which can be *nrj* for the photon energy, *delay* in which case the delay stage position will be converted in picoseconds and corrected but the BAM, or another slow data channel. Specific pulse pattern can be defined, such as:

```
['pumped', 'unpumped']
```

which will be repeated. XGM data will also be binned similarly to the DSSC data.

Since this data reduction step can be quite time consuming for large datasets, it is recommended to launch the notebook via a SLURM script. The script can be downloaded from `scripts/bin_dssc_module_job.sh` and reads as:

```

1  #!/bin/bash
2  #SBATCH -N 1
3  #SBATCH --partition=exfel
4  #SBATCH --time=12:00:00
5  #SBATCH --mail-type=END,FAIL
6  #SBATCH --output=logs/%j-%x.out
7
8  while getopts ":p:d:r:k:m:x:b:" option
9  do
10     case $option in
11         p) PROPOSAL="$OPTARG";;
12         d) DARK="$OPTARG";;
13         r) RUN="$OPTARG";;
14         k) KERNEL="$OPTARG";;
15         m) MODULE_GROUP="$OPTARG";;
16         x) XAXIS="$OPTARG";;
17         b) BINWIDTH="$OPTARG";;
18         \?) echo "Unknown option"
19             exit 1;;
20         :) echo "Missing option for input flag"
21             exit 1;;
22     esac
23 done
24
25 # Load xfel environment

```

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```

26 source /etc/profile.d/modules.sh
27 module load exfel exfel-python
28
29 echo processing run $RUN
30 PDIR=$(findxfel $PROPOSAL)
31 PPROPOSAL="p$(printf '%06d' $PROPOSAL)"
32 RDIR="$PDIR/usr/processed_runs/r$(printf '%04d' $RUN)"
33 mkdir $RDIR
34
35 NB='Dask DSSC module binning.ipynb'
36
37 # kernel list can be seen from 'jupyter kernelspec list'
38 if [ -z "${KERNEL}" ]; then
39     KERNEL="toolbox_$PPROPOSAL"
40 fi
41
42 python -c "import papermill as pm; pm.execute_notebook(\
43     '$NB', \
44     '$RDIR/output$MODULE_GROUP.ipynb', \
45     kernel_name='$KERNEL', \
46     parameters=dict(proposalNB=int('$PROPOSAL'), \
47                     dark_runNB=int('$DARK'), \
48                     runNB=int('$RUN'), \
49                     module_group=int('$MODULE_GROUP'), \
50                     path='$RDIR/', \
51                     xaxis='$XAXIS', \
52                     bin_width=float('$BINWIDTH')))"

```

It is launched with the following:

```

sbatch ./bin_dssc_module_job.sh -p 2719 -d 180 -r 179 -m 0 -x delay -b 0.1
sbatch ./bin_dssc_module_job.sh -p 2719 -d 180 -r 179 -m 1 -x delay -b 0.1
sbatch ./bin_dssc_module_job.sh -p 2719 -d 180 -r 179 -m 2 -x delay -b 0.1
sbatch ./bin_dssc_module_job.sh -p 2719 -d 180 -r 179 -m 3 -x delay -b 0.1

```

where 2719 is the proposal number, 180 is the dark run number, 179 is the run number and 0, 1, 2 and 3 are the 4 module groups, each job processing a set of 4 DSSC modules, delay is the bin axis and 0.1 is the bin width.

The result will be 16 \*.h5 files, one per module, saved in the folder specified in the script, a copy of which can be found in the *scripts* folder in the toolbox source. These files can then be loaded and combined with:

```

import xarray as xr
data = xr.open_mfdataset(path + '/*.h5', parallel=True, join='inner')

```

### DSSC azimuthal integration

Azimuthal integration can be performed with `pyFAI` which can utilize the hexagonal pixel shape information from the DSSC geometry to split the intensity in a pixel in the bins covered by it. An example notebook Azimuthal integration of DSSC with `pyFAI.ipynb` is available.

A second example notebook `DSSC scattering time-delay.ipynb` demonstrates how to:

- refine the geometry such that the scattering pattern is centered before azimuthal integration
- perform azimuthal integration on a time delay dataset with `xr.apply_ufunc` for multiprocessing.
- plot a two-dimensional map of the scattering change as function of scattering vector and time delay
- integrate certain scattering vector range and plot a time trace

### DSSC fine timing

When DSSC is reused after a period of inactivity or when the DSSC gain setting use a different operation frequency the DSSC fine trigger delay needs to be checked. To analysis runs recorded with different fine delay, one can use the notebook `DSSC fine delay with SCS toolbox.ipynb`.

### DSSC quadrant geometry

To check or refined the DSSC geometry or quadrants position, the following notebook can be used `DSSC create geometry.ipynb`.

### Legacy DSSC binning procedure

Most of the functions within `toolbox_scs.detectors` can be accessed directly. This is useful during development, or when working in a non-standardized way, which is often necessary during data evaluation. For frequent routines there is the possibility to use `dssc` objects that guarantee consistent data structure, and reduce the amount of recurring code within the notebook.

- bin data using `toolbox_scs.tbdet` -> *to be documented*.
- bin data using the `DSSCBinner`.
- post processing, data analysis -> *to be documented*

### 3.1.7 Photo-Electron Spectrometer (PES)

- Basic analysis of PES spectra.

### 3.1.8 BOZ: Beam-Splitting Off-axis Zone plate analysis

The BOZ analysis consists of 4 notebooks and a script. The first notebook `BOZ analysis part I.a Correction determination` is used to determine all the necessary correction, that is the flat field correction from the zone plate optics and the non-linearity correction from the DSSC gain. The inputs are a dark run and a run with X-rays on three broken or empty membranes. For the latter, an alternative is to use pre-edge data on an actual sample. The result is a JSON file that contains the flat field and non-linearity correction as well as the parameters used for their determination such that this can be reproduced and investigated in case of issues. The determination of the flat field correction is rather quick, few minutes and is the most important correction for the change in XAS computed from the -1st and +1st order. For quick correction of the online preview one can bypass the non-linearity calculation by taking the JSON file as soon as

it appears. The determination of the non-linearity correction is a lot longer and can take some 2 to 8 hours depending on the number of pulses in the train. For this reason, the computation can also be done on GPUs in 30min instead. A GPU notebook adapted for CHEM experiment with liquid jet and normalization implement for S K-edge is available at OnlineGPU BOZ analysis part I.a Correction determination S K-edge.

The other option is to use a script that can be downloaded from `scripts/boz_parameters_job.sh` and reads as:

```

1  #!/bin/bash
2  #SBATCH -N 1
3  #SBATCH --partition=allgpu
4  #SBATCH --constraint=V100
5  #SBATCH --time=2:00:00
6  #SBATCH --mail-type=END,FAIL
7  #SBATCH --output=logs/%j-%x.out
8
9  ROISTH='1'
10 SATLEVEL='500'
11 MODULE='15'
12
13 while getopts ":p:d:r:k:g:t:s:m:" option
14 do
15     case $option in
16         p) PROPOSAL="$OPTARG";;
17         d) DARK="$OPTARG";;
18         r) RUN="$OPTARG";;
19         k) KERNEL="$OPTARG";;
20         g) GAIN="$OPTARG";;
21         t) ROISTH="$OPTARG";;
22         s) SATLEVEL="$OPTARG";;
23         m) MODULE="$OPTARG";;
24         \?) echo "Unknown option"
25             exit 1;;
26         :) echo "Missing option for input flag"
27             exit 1;;
28     esac
29 done
30
31 # Load xfel environment
32 source /etc/profile.d/modules.sh
33 module load exfel exfel-python
34
35 echo processing run $RUN
36 PDIR=$(findxfel $PROPOSAL)
37 PPROPOSAL="p$(printf '%06d' $PROPOSAL)"
38 RDIR="$PDIR/usr/processed_runs/r$(printf '%04d' $RUN)"
39 mkdir $RDIR
40
41 NB='BOZ analysis part I.a Correction determination.ipynb'
42
43 # kernel list can be seen from 'jupyter kernelspec list'
44 if [ -z "${KERNEL}" ]; then
45     KERNEL="toolbox_$$PPROPOSAL"
46 fi
47

```

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```
48 python -c "import papermill as pm; pm.execute_notebook(\
49     '$NB', \
50     '$RDIR/output.ipynb', \
51     kernel_name='$KERNEL', \
52     parameters=dict(proposal=int('$PROPOSAL'), \
53                     darkrun=int('$DARK'), \
54                     run=int('$RUN'), \
55                     module=int('$MODULE'), \
56                     gain=float('$GAIN'), \
57                     rois_th=float('$ROIsth'), \
58                     sat_level=int('$SATLEVEL'))"
```

It uses the first notebook and is launched via slurm:

```
sbatch ./boz_parameters_job.sh -p 2937 -d 615 -r 614 -g 3
```

where 2937 is the proposal run number, where 615 is the dark run number, 614 is the run on 3 broken membranes and 3 is the DSSC gain in photon per bin. The proposal run number is defined inside the script file.

The second notebook BOZ analysis part I.b Correction validation can be used to check how well the calculated correction still work on a characterization run recorded later, i.e. on 3 broken membrane or empty membranes.

The third notebook BOZ analysis part II.1 Small data then use the JSON correction file to load all needed corrections and process an run, saving the rois extracted DSSC as well as aligning them to photon energy and delay stage in a small data h5 file.

That small data h5 file can then be loaded and the data binned to compute a spectrum or a time resolved XAS scan using the fourth and final notebook BOZ analysis part II.2 Binning

### 3.1.9 Point detectors

Detectors that produce one point per pulse, or 0D detectors, are all handled in a similar way. Such detectors are, for instance, the X-ray Gas Monitor (XGM), the Transmitted Intensity Monitor (TIM), the electron Bunch Arrival Monitor (BAM) or the photo diodes monitoring the PP laser.

### 3.1.10 HRIXS

- Analyzing HRIXS data

### 3.1.11 Viking spectrometer

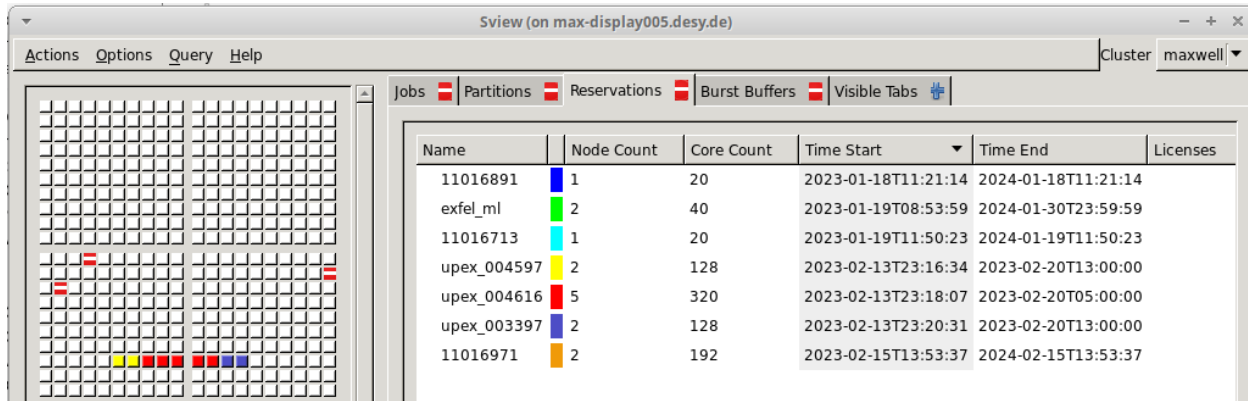
- Analysis of Viking spectrometer data

### 3.1.12 SLURM, sbatch, partition, reservation

Scripts launched by `sbatch` command can employ magic cookie with `#SBATCH` to pass options SLURM, such as which partition to run on. To work, the magic cookie has to be at the beginning of the line. This means that:

- to comment out a magic cookie, adding another “#” before it is sufficient
- to comment a line to detail what the option does, it is best practice to put the comment on the line before

Reserved partition are of the form “`upex_003333`” where 3333 is the proposal number. To check what reserved partition are existing, their start and end date, one can `ssh` to `max-display` and use the command `sview`.



The screenshot shows the sview interface for the 'maxwell' cluster. On the left is a grid representing node status. On the right is a table of reservations with the following data:

Name	Node Count	Core Count	Time Start	Time End	Licenses
11016891	1	20	2023-01-18T11:21:14	2024-01-18T11:21:14	
exfel_ml	2	40	2023-01-19T08:53:59	2024-01-30T23:59:59	
11016713	1	20	2023-01-19T11:50:23	2024-01-19T11:50:23	
upex_004597	2	128	2023-02-13T23:16:34	2023-02-20T13:00:00	
upex_004616	5	320	2023-02-13T23:18:07	2023-02-20T05:00:00	
upex_003397	2	128	2023-02-13T23:20:31	2023-02-20T13:00:00	
11016971	2	192	2023-02-15T13:53:37	2024-02-15T13:53:37	

To use a reserved partition with `sbatch`, one can use the magic cookie

```
#SBATCH --reservation=upex_003333
```

instead of the usual

```
#SBATCH --partition=upex
```

## 3.2 Maintainers

### 3.2.1 Creating a Toolbox environment in the proposal folder

A Toolbox environment can be created by running the following commands in Maxwell:

```
module load exfel exfel-python
scs-create-toolbox-env --proposal <PROPOSAL>
```

where `<PROPOSAL>` is the desired proposal number. This will create a Python environment and will download and install the Toolbox source code. It will result to the creation of the following folders in the path `<PROPOSAL_PATH>/scratch`.

```
<PROPOSAL_PATH>/scratch/
├─ checkouts/
│   └─ toolbox_<PROPOSAL>/
│       └─ <source code>
├─ envs/
│   └─ toolbox_<PROPOSAL>/
│       └─ <Python files>
```

The `checkouts` folder contains the Toolbox source codes, correspondingly labeled according to the environment identifier, which is the proposal number by default. The downloaded code defaults to the **master** version at the time when the environment is created.

The `envs` folder contains the Python environment with the packages necessary to run the Toolbox. It is also correspondingly labeled according to the environment identifier, which is the proposal number by default.

---

**Note:** One can find the proposal path by running `findxfel <PROPOSAL>`.

---

It is a good practice to tag the Toolbox version at a given milestone. This version can be then supplied to the script as:

```
scs-create-toolbox-env --proposal <PROPOSAL> --version <VERSION>
```

It might also be helpful to supply an identifier to distinguish environments from each other. This can be done by running:

```
scs-create-toolbox-env --proposal <PROPOSAL> --identifier <IDENTIFIER>
```

The environment would then be identified as `toolbox_<IDENTIFIER>` instead of `toolbox_<PROPOSAL>`.

### 3.2.2 Installing additional packages

In order to install additional packages in a Toolbox environment, one should run the following commands:

```
cd <PROPOSAL_PATH>/scratch/  
source envs/toolbox_<IDENTIFIER>/bin/activate  
pip install ...
```

There's no need to load the `exfel` module.

### 3.2.3 Updating the source codes

Should there be desired changes in the Toolbox codes, may it be bug fixes or additional features during beam-time, one can freely modify the source codes in the following path: `<PROPOSAL_PATH>/scratch/checkouts/toolbox_<IDENTIFIER>`. The contents of this folder should be a normal git repository. Any changes can be easily done (e.g., editing a line of code, checking out a different branch, etc.) and such changes are immediately reflected on the environment.

## 3.3 Release Notes

### 3.3.1 unreleased

- **Bug fixes**
  - fix [issue:75](#) regarding pulse Id assignment when reading BAM data [MR:272](#)
  - fix [issue:80](#) regarding new bunch pattern table size when reading BAM data [MR:279](#)
  - fix [issue:84](#) regarding loading only a given amount of BOZ DSSC data in memory [MR:288](#)
  - fix [issue:86](#) regarding loading XGM [MR:291](#)
  - fix [issue:88](#) regarding loading data from multiple folders [MR:303](#)



- **Improvements**

- update documentation on knife-edge scan and fluence calculation [MR:276](#), [MR:278](#)
- update scannerY mnemonics [MR:281](#)
- move loading logic to mnemonics [MR:283](#), [MR:286](#)
- add MaranaX mnemonics [MR:285](#)
- add Chem diagnostics and Gotthard II mnemonics [MR:292](#)
- make hRIXS centroid threshold configurable [MR:298](#)
- drop MaranaX non-existing mnemonics and add attributes on dataset [MR:300](#)
- streamline digitizer functions [MR:304](#)
- add BAM average and BAM feedbacks mnemonics, Viking mnemonics [MR:305](#), [MR:306](#)
- improved function to load PES spectra [MR:309](#)
- Gotthard-II mnemonics and pulse alignment [MR:310](#), [MR:311](#)

- **New Features**

- fix [issue:75](#) add frame counts when aggregating RIXS data [MR:274](#)
- BOZ normalization using 2D flat field polylines for S K-edge [MR:293](#)
- BOZ GPU notebook [MR:294](#)
- update hRIXS class for MaranaX [MR:287](#)
- introduce MaranaX class for parallelized centroiding [MR:297](#)
- New PES functions to save / load average traces [MR:309](#)

### 3.3.2 1.7.0

- **Bug fixes**

- fix [issue:61](#) regarding sign of XAS in some cases [MR:207](#)
- Use `xarray.values` instead of `.to_numpy()` for backward-compatibility [MR:214](#)
- fix [issue:23](#) regarding API documentation generation [MR:221](#)
- fix [issue:64](#) regarding loading a subset of trains [MR:226](#), [MR:230](#)
- fix [issue:67](#) regarding bunch pattern [MR:245](#)
- fix [issue:44](#) regarding notebook for DSSC geometry quadrants alignment [MR:247](#)
- fix [issue:52](#) use extra-geom detector helper function for azimuthal integration [MR:248](#)
- fix [issue:18](#) regarding using reserved partition with `sbatch` [MR:250](#)
- fix [issue:68](#) now using `findxfel` command [MR:256](#)
- fix [issue:69](#) to speed up BOZ Small data and deal with missing intra-darks [MR:256](#)
- fix [issue:71](#) regarding rounding error in BOZ analysis related to timing [MR:256](#)
- fix [issue:40](#) update documentation regarding toolbox deployment folder in scratch [MR:268](#)

- **Improvements**

- remove calls to `matplotlib.tight_layout` [MR:206](#)

- Improved hRIXS class and utilities [MR:182](#)
- Documentation on extracting digitizer peaks, clean up of digitizer functions [MR:215](#)
- Improved peak-finding algorithm for digitizer traces [MR:216](#), [MR:227](#)
- Only load bunch pattern table when necessary [MR:234](#), [MR:245](#)
- Document the HRIXS class [MR:238](#)
- notebook example of DSSC azimuthal integration for time delay scans [MR:249](#)
- provide drop-intra-darks option in BOZ analysis [MR:256](#)
- improve automatic ROIs finding for BOZ analysis [MR:256](#)
- prevent flat field correction from turning negative in BOZ analysis [MR:259](#)
- update documentation to the new exfel-python environment [MR:266](#)

- **New Features**

- Read signal description from Fast ADC and ADQ412 digitizers [MR:209](#), [MR:212](#)
- Mnemonics for XRD devices [MR:208](#)
- Add function to align OL to FEL pulse Id [MR:218](#)
- Add reflectivity routine [MR:218](#)
- Possibility to extract run values of mnemonics [MR:220](#), [MR:232](#)
- Add `get_undulator_config` function [MR:225](#)
- Document the HRIXS class [MR:238](#)
- Include double counts for hRIXS SPC algorithms [MR:239](#)
- Add Viking spectrometer analysis class [MR:240](#)
- Add GPU acceleration for BOZ correction determination [MR:254](#)
- Issues warning when loading data with > 5% missing trains [MR:263](#)

### 3.3.3 1.6.0

- **Bug fixes**

- fix [issue:45](#) SLURM scripts embedded in and download link available from documentation [MR:171](#)
- fix [issue:8](#) regarding azimuthal integration with pyFAI and hexagonal DSSC pixel splitting by providing an example notebook [MR:174](#)
- fix [issue:46](#) with a change in dask groupby mean behavior [MR:174](#)
- fix [issue:47](#) SLURM script not using the correct kernel [MR:176](#)
- fix [issue:51](#) make sure that BAM units are in ps [MR:183](#)
- fix [issue:50](#) and [issue:54](#) relating to package dependencies
- fix [issue:57](#) adds target mono energy mnemonic
- fix [issue:55](#) implementing dask auto rechunking in notebooks
- fix [issue:53](#) wrong flat field correction sometimes being calculated
- fix [issue:56](#) future warning on `xarray.ufuncs` [MR:189](#)

- **Improvements**

- update version of BAM mnemonics [MR:175](#)
- update version GATT-related mnemonics, add *transmission\_col2* [MR:172](#)
- reorganize the Howto section [MR:169](#)
- improve SLURM scripts with named arguments [MR:176](#)
- adds notebook for DSSC fine timing analysis [MR:184](#) and [MR:185](#)
- numerous improvements for the flat field correction calculation in the BOZ analysis, including fitting domain functions, hexagonal pixel lattice, possibility to switch off flat field symmetry constraints and a refine fit function with regularization term [MR:186](#)
- simplifies flat field calculation by using directly the refined fit procedure which works with far fewer input parameters [MR:202](#)

- **New Features**

- add routine for fluence calibration [MR:180](#)
- add Fast ADC 2 mnemonics [MR:200](#)

### 3.3.4 1.5.0

- **Bug fixes**

- fix [issue:39](#) providing a changelog in the documentation [MR:164](#)
- fix [issue:37](#) BOZ analysis [MR:158](#)
- fix [issue:36](#) mnemonics [MR:159](#)
- fix [issue:35](#) BOZ notebook dependencies [MR:157](#)
- fix [issue:34](#) BOZ time delay calculations and plotting [MR:154](#)
- fix [issue:32](#) significantly speeding up in XAS binning calculation [MR:151](#)
- fix [issue:27](#) improving BOZ analysis [MR:146](#)
- fix [issue:28](#) pp pattern in DSSC dask binning [MR:144](#)
- fix [issue:26](#) several BOZ analysis improvements [MR:135](#)

- **Improvements**

- checks if single-version mnemonics is in all\_sources [MR:163](#)
- add `get_bam_params()` [MR:160](#)
- only check keys if mnemonic has more than one version `commit:ae724d3c`
- add FFT focus lens mnemonics [MR:156](#)
- add dask as dependency [MR:155](#)
- renamed FFT sample Z mnemonics [MR:153](#)
- add virtual sample camera `LLC_webcam1` into mnemonics [MR:152](#)
- fix digitizer check params [MR:149](#)
- improve installation instruction [MR:145](#)
- add Newton camera [MR:142](#)

- simplified `mnemonics_for_run()` [commit:3cc98c16](#)
- adds Horizontal FDM to mnemonics [MR:141](#)
- add setup documentation [MR:140](#)
- numerous PES fixes [MR:143](#), [MR:130](#), [MR:129](#), [MR:138](#), [MR:137](#)
- change in FFT sample Z mnemonics [MR:125](#) and [MR:124](#)
- add MTE3 camera [MR:123](#)
- add KB benders averager [MR:120](#) and [MR:119](#)

- **New Features**

- implement the Beam-splitting Off-axis Zone-plate analysis: [MR:150](#), [MR:139](#), [MR:136](#), [MR:134](#), [MR:133](#), [MR:132](#), [MR:131](#), [MR:128](#), [MR:127](#), [MR:126](#), [MR:115](#)
- introduce dask assisted DSSC binning, fixing [issue:24](#) and [issue:17](#)

### 3.3.5 1.4.0

- **Bug fixes**

- fix [issue:22](#) using extra-data read machinery [MR:105](#)
- fix [issue:21](#) and [issue:12](#) introducing mnemonics version [MR:104](#)

- **Improvements**

- fix `get_array()`, add wrappers to some of *extra\_data* basic functions [MR:116](#)
- new FastADC mnemonics [MR:112](#)
- refactor packaging [MR:106](#)
- add `load_bpt()` function [commit:9e2c1107](#)
- add XTD10 MCP mnemonics [commit:8b550c9b](#)
- add `digitizer_type()` function [commit:75eb0bca](#)
- separate FastADC and ADQ412 code [commit:939d32b9](#)
- documentation centralized on [rtd.xfel.eu](#) [MR:103](#)
- simplify digitizer functions and pulseId coordinates assignment for XGM and digitizers [MR:100](#)

- **New Features**

- base knife-edge scan analysis implementation [MR:107](#)
- add PES [MR:108](#)
- integrate documentation to [rtd.xfel.eu](#) [MR:103](#) and [MR:99](#)

### 3.3.6 1.1.2rc1

- **Bug Fixes**
- **Improvements**
- **New Feature**
  - introduce change in package structure, sphinx documentation and DSSC binning class [MR:87](#)

## 3.4 API Reference

This page contains auto-generated API reference documentation<sup>1</sup>.

### 3.4.1 toolbox\_scs

#### Subpackages

`toolbox_scs.base`

#### Subpackages

`toolbox_scs.base.tests`

#### Submodules

`toolbox_scs.base.tests.test_knife_edge`

#### Module Contents

#### Functions

---

`test_range_mask()`

---

`test_prepare_arrays_nans()`

---

`test_prepare_arrays_size()`

---

`test_prepare_arrays_range()`

---

`test_knife_edge_base()`

---

`_with_values(array, value[, num])`

---

`toolbox_scs.base.tests.test_knife_edge.test_range_mask()`

---

<sup>1</sup> Created with sphinx-autoapi

```

toolbox_scs.base.tests.test_knife_edge.test_prepare_arrays_nans()
toolbox_scs.base.tests.test_knife_edge.test_prepare_arrays_size()
toolbox_scs.base.tests.test_knife_edge.test_prepare_arrays_range()
toolbox_scs.base.tests.test_knife_edge.test_knife_edge_base()
toolbox_scs.base.tests.test_knife_edge._with_values(array, value, num=5)

```

## Submodules

```
toolbox_scs.base.knife_edge
```

## Module Contents

### Functions

<code>knife_edge(positions, intensities[, axisRange, p0])</code>	Calculates the beam radius at $1/e^2$ from a knife-edge scan by
<code>knife_edge_base(positions, intensities[, axisRange, p0])</code>	The base implementation of the knife-edge scan analysis.

```
toolbox_scs.base.knife_edge.knife_edge(positions, intensities, axisRange=None, p0=None)
```

Calculates the beam radius at  $1/e^2$  from a knife-edge scan by fitting with erfc function:  $f(a,b,u) = a \cdot \text{erfc}(u) + b$  or where  $u = \sqrt{2} \cdot (x-x_0)/w_0$  with  $w_0$  the beam radius at  $1/e^2$  and  $x_0$  the beam center.

#### Parameters

- **positions** (*np.ndarray*) – Motor position values, typically 1D
- **intensities** (*np.ndarray*) – Intensity values, could be either 1D or 2D, with the number or rows equivalent with the position size
- **axisRange** (*sequence of two floats or None*) – Edges of the scanning axis between which to apply the fit.
- **p0** (*list of floats, numpy 1D array*) – Initial parameters used for the fit:  $x_0$ ,  $w_0$ ,  $a$ ,  $b$ . If None, a beam radius of 100  $\mu\text{m}$  is assumed.

#### Returns

- **width** (*float*) – The beam radius at  $1/e^2$
- **std** (*float*) – The standard deviation of the width

```
toolbox_scs.base.knife_edge.knife_edge_base(positions, intensities, axisRange=None, p0=None)
```

The base implementation of the knife-edge scan analysis.

Calculates the beam radius at  $1/e^2$  from a knife-edge scan by fitting with erfc function:  $f(a,b,u) = a \cdot \text{erfc}(u) + b$  or where  $u = \sqrt{2} \cdot (x-x_0)/w_0$  with  $w_0$  the beam radius at  $1/e^2$  and  $x_0$  the beam center.

#### Parameters

- **positions** (*np.ndarray*) – Motor position values, typically 1D
- **intensities** (*np.ndarray*) – Intensity values, could be either 1D or 2D, with the number or rows equivalent with the position size

- **axisRange** (*sequence of two floats or None*) – Edges of the scanning axis between which to apply the fit.
- **p0** (*list of floats, numpy 1D array*) – Initial parameters used for the fit: x0, w0, a, b. If None, a beam radius of 100 um is assumed.

**Returns**

- **popt** (*sequence of floats or None*) – The parameters of the resulting fit.
- **pcov** (*sequence of floats*) – The covariance matrix of the resulting fit.

**Package Contents****Functions**


---

*knife\_edge*

---

*knife\_edge\_base*(positions, intensities[, axisRange, p0]) The base implementation of the knife-edge scan analysis.

---

**Attributes**


---

*\_\_all\_\_*

---

toolbox\_scs.base.**knife\_edge**(positions, intensities, axisRange=None, p0=None)

Calculates the beam radius at  $1/e^2$  from a knife-edge scan by fitting with erfc function:  $f(a,b,u) = a \cdot \text{erfc}(u) + b$  or where  $u = \sqrt{2} \cdot (x-x_0)/w_0$  with  $w_0$  the beam radius at  $1/e^2$  and  $x_0$  the beam center.

**Parameters**

- **positions** (*np.ndarray*) – Motor position values, typically 1D
- **intensities** (*np.ndarray*) – Intensity values, could be either 1D or 2D, with the number or rows equivalent with the position size
- **axisRange** (*sequence of two floats or None*) – Edges of the scanning axis between which to apply the fit.
- **p0** (*list of floats, numpy 1D array*) – Initial parameters used for the fit: x0, w0, a, b. If None, a beam radius of 100 um is assumed.

**Returns**

- **width** (*float*) – The beam radius at  $1/e^2$
- **std** (*float*) – The standard deviation of the width

toolbox\_scs.base.**knife\_edge\_base**(positions, intensities, axisRange=None, p0=None)

The base implementation of the knife-edge scan analysis.

Calculates the beam radius at  $1/e^2$  from a knife-edge scan by fitting with erfc function:  $f(a,b,u) = a \cdot \text{erfc}(u) + b$  or where  $u = \sqrt{2} \cdot (x-x_0)/w_0$  with  $w_0$  the beam radius at  $1/e^2$  and  $x_0$  the beam center.

**Parameters**

- **positions** (*np.ndarray*) – Motor position values, typically 1D
- **intensities** (*np.ndarray*) – Intensity values, could be either 1D or 2D, with the number or rows equivalent with the position size
- **axisRange** (*sequence of two floats or None*) – Edges of the scanning axis between which to apply the fit.
- **p0** (*list of floats, numpy 1D array*) – Initial parameters used for the fit: x0, w0, a, b. If None, a beam radius of 100 um is assumed.

### Returns

- **popt** (*sequence of floats or None*) – The parameters of the resulting fit.
- **pcov** (*sequence of floats*) – The covariance matrix of the resulting fit.

`toolbox_scs.base.__all__`

`toolbox_scs.detectors`

### Submodules

`toolbox_scs.detectors.azimuthal_integrator`

### Module Contents

### Classes

---

*AzimuthalIntegrator*

---

*AzimuthalIntegratorDSSC*

---

**class** `toolbox_scs.detectors.azimuthal_integrator.AzimuthalIntegrator`(*imageshape, center, polar\_range, aspect=204 / 236, \*\*kwargs*)

Bases: `object`

**\_calc\_dist\_array**(*shape, center, aspect*)

Calculate pixel coordinates for the given shape.

**\_calc\_indices**(*\*\*kwargs*)

Calculates the list of indices for the flattened image array.

**\_calc\_polar\_mask**(*polar\_range*)

**calc\_q**(*distance, wavelength*)

Calculate momentum transfer coordinate.

### Parameters

- **distance** (*float*) – Sample - detector distance in meter
- **wavelength** (*float*) – wavelength of scattered light in meter



**Returns****deltaq** – Momentum transfer coordinate in 1/m**Return type**

np.ndarray

`__call__(image)`

```
class toolbox_scs.detectors.azimuthal_integrator.AzimuthalIntegratorDSSC(geom, polar_range,
                                                                    dxdy=(0, 0),
                                                                    **kwargs)
```

Bases: *AzimuthalIntegrator*`_calc_dist_array(geom, dxdy)`

Calculate pixel coordinates for the given shape.

**toolbox\_scs.detectors.bam\_detectors**

Beam Arrival Monitor related sub-routines

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(contributions preferably comply with pep8 code structure guidelines.)

**Module Contents****Functions**

<code>get_bam(run[, mnemonics, merge_with, bunchPattern, ...])</code>	Load beam arrival monitor (BAM) data and align their pulse ID
<code>get_bam_params(run[, mnemo_or_source])</code>	Extract the run values of bamStatus[1-3] and bamError.

```
toolbox_scs.detectors.bam_detectors.get_bam(run, mnemonics=None, merge_with=None,
                                             bunchPattern='sase3', pulseIds=None)
```

Load beam arrival monitor (BAM) data and align their pulse ID according to the bunch pattern. Sources can be loaded on the fly via the mnemonics argument, or processed from an existing data set (*merge\_with*).**Parameters**

- **run** (*extra\_data.DataCollection*) – DataCollection containing the bam data.
- **mnemonics** (*str or list of str*) – mnemonics for BAM, e.g. “BAM1932M” or [“BAM414”, “BAM1932M”]. the arrays are either taken from *merge\_with* or loaded from the DataCollection run.
- **merge\_with** (*xarray Dataset*) – If provided, the resulting Dataset will be merged with this one. If *merge\_with* contains variables in *mnemonics*, they will be selected, aligned and merged.
- **bunchPattern** (*str*) – ‘sase1’ or ‘sase3’ or ‘scs\_ppl’, bunch pattern used to extract peaks. The pulse ID dimension will be named ‘sa1\_pId’, ‘sa3\_pId’ or ‘ol\_pId’, respectively.
- **pulseIds** (*list, 1D array*) – Pulse Ids. If None, they are automatically loaded.

**Returns**merged with Dataset *merge\_with* if provided.

### Return type

xarray Dataset with pulse-resolved BAM variables aligned,

### Example

```
>>> import toolbox_scs as tb
>>> run = tb.open_run(2711, 303)
>>> bam = tb.get_bam(run, 'BAM1932S')
```

`toolbox_scs.detectors.bam_detectors.get_bam_params(run, mnemo_or_source='BAM1932S')`

Extract the run values of bamStatus[1-3] and bamError.

### Parameters

- **run** (*extra\_data.DataCollection*) – DataCollection containing the bam data.
- **mnemo\_or\_source** (*str*) – mnemonic of the BAM, e.g. 'BAM414', or source name, e.g. 'SCS\_ILH\_LAS/DOOCS/BAM\_414\_B2.

### Returns

**params** – dictionary containing the extracted parameters.

### Return type

dict

---

**Note:** The extracted parameters are run values, they do not reflect any possible change during the run.

---

## `toolbox_scs.detectors.digitizers`

Digitizers related sub-routines

Copyright (2021) SCS Team.

(contributions preferably comply with pep8 code structure guidelines.)

## Module Contents

### Functions

<code>get_peaks(run, data, mnemonic[, useRaw, autoFind, ...])</code>	Extract peaks from one source (channel) of a digitizer.
<code>get_dig_avg_trace(run, mnemonic[, ntrains])</code>	Compute the average over ntrains evenly spaced across all trains
<code>check_peak_params(run, mnemonic[, raw_trace, ntrains, ...])</code>	Checks and plots the peak parameters (pulse window and baseline window)
<code>get_tim_peaks(run[, mnemonic, merge_with, ...])</code>	Automatically computes TIM peaks. Sources can be loaded on the
<code>get_laser_peaks(run[, mnemonic, merge_with, ...])</code>	Extracts laser photodiode signal (peak intensity) from Fast ADC
<code>get_digitizer_peaks(run, mnemonic[, merge_with, ...])</code>	Automatically computes digitizer peaks. A source can be loaded on the
<code>digitizer_signal_description(run[, digitizer])</code>	Check for the existence of signal description and return all corresponding

`toolbox_scs.detectors.digitizers.get_peaks`(*run, data, mnemonic, useRaw=True, autoFind=True, integParams=None, bunchPattern='sase3', bpt=None, extra\_dim=None, indices=None*)

Extract peaks from one source (channel) of a digitizer.

#### Parameters

- **run** (*extra\_data.DataCollection*) – DataCollection containing the digitizer data
- **data** (*xarray DataArray or str*) – array containing the raw traces or peak-integrated values from the digitizer. If str, must be one of the ToolBox mnemonics. If None, the data is loaded via the source and key arguments.
- **mnemonic** (*str or dict*) – ToolBox mnemonic or dict with source and key as in {‘source’: ‘SCS.UTC1\_ADQ/ADC/1:network’, ‘key’: ‘digitizers.channel\_1\_A.raw.samples’}
- **useRaw** (*bool*) – If True, extract peaks from raw traces. If False, uses the APD (or peaks) data from the digitizer.
- **autoFind** (*bool*) – If True, finds integration parameters by inspecting the average raw trace. Only valid if useRaw is True.
- **integParams** (*dict*) – dictionary containing the integration parameters for raw trace integration: ‘pulseStart’, ‘pulseStop’, ‘baseStart’, ‘baseStop’, ‘period’, ‘npulses’. Not used if autoFind is True. All keys are required when bunch pattern is missing.
- **bunchPattern** (*str*) – match the peaks to the bunch pattern: ‘sase1’, ‘sase3’, ‘scs\_ppl’. This will dictate the name of the pulse ID coordinates: ‘sa1\_pId’, ‘sa3\_pId’ or ‘scs\_ppl’.
- **bpt** (*xarray DataArray*) – bunch pattern table
- **extra\_dim** (*str*) – Name given to the dimension along the peaks. If None, the name is given according to the bunchPattern.
- **indices** (*array, slice*) – indices from the peak-integrated data to retrieve. Only required when bunch pattern is missing and useRaw is False.

#### Return type

`xarray.DataArray` containing digitizer peaks with pulse coordinates

`toolbox_scs.detectors.digitizers.get_dig_avg_trace(run, mnemonic, ntrains=None)`

Compute the average over ntrains evenly spaced accross all trains of a digitizer trace.

#### Parameters

- **run** (*extra\_data.DataCollection*) – DataCollection containing the digitizer data.
- **mnemonic** (*str*) – ToolBox mnemonic of the digitizer data, e.g. ‘MCP2apd’.
- **ntrains** (*int*) – Number of trains used to calculate the average raw trace. If None, all trains are used.

#### Returns

**trace** – The average digitizer trace

#### Return type

DataArray

`toolbox_scs.detectors.digitizers.check_peak_params(run, mnemonic, raw_trace=None, ntrains=200, params=None, plot=True, show_all=False, bunchPattern='sase3')`

Checks and plots the peak parameters (pulse window and baseline window of a raw digitizer trace) used to compute the peak integration. These parameters are either set by the digitizer peak-integration settings, or are determined by a peak finding algorithm (used in `get_tim_peaks` or `get_fast_adc_peaks`) when the inputs are raw traces. The parameters can also be provided manually for visual inspection. The plot either shows the first and last pulse of the trace or the entire trace.

#### Parameters

- **run** (*extra\_data.DataCollection*) – DataCollection containing the digitizer data.
- **mnemonic** (*str*) – ToolBox mnemonic of the digitizer data, e.g. ‘MCP2apd’.
- **raw\_trace** (*optional, 1D numpy array or xarray DataArray*) – Raw trace to display. If None, the average raw trace over ntrains of the corresponding channel is loaded (this can be time-consuming).
- **ntrains** (*optional, int*) – Only used if raw\_trace is None. Number of trains used to calculate the average raw trace of the corresponding channel.
- **plot** (*bool*) – If True, displays the raw trace and peak integration regions.
- **show\_all** (*bool*) – If True, displays the entire raw trace and all peak integration regions (this can be time-consuming). If False, shows the first and last pulse according to the bunchPattern.
- **bunchPattern** (*optional, str*) – Only used if plot is True. Checks the bunch pattern against the digitizer peak parameters and shows potential mismatch.

#### Return type

dictionnary of peak integration parameters

`toolbox_scs.detectors.digitizers.get_tim_peaks(run, mnemonic=None, merge_with=None, bunchPattern='sase3', integParams=None, keepAllSase=False)`

Automatically computes TIM peaks. Sources can be loaded on the fly via the mnemonics argument, or processed from an existing data set (`merge_with`). The bunch pattern table is used to assign the pulse id coordinates.

#### Parameters

- **run** (*extra\_data.DataCollection*) – DataCollection containing the digitizer data.
- **mnemonic** (*str*) – mnemonics for TIM, e.g. “MCP2apd”.

- **merge\_with** (*xarray Dataset*) – If provided, the resulting Dataset will be merged with this one. The TIM variables of merge\_with (if any) will also be computed and merged.
- **bunchPattern** (*str*) – ‘sase1’ or ‘sase3’ or ‘scs\_ppl’, bunch pattern used to extract peaks. The pulse ID dimension will be named ‘sa1\_pId’, ‘sa3\_pId’ or ‘ol\_pId’, respectively.
- **integParams** (*dict*) – dictionary for raw trace integration, e.g. {‘pulseStart’:100, ‘pulsestop’:200, ‘baseStart’:50, ‘baseStop’:99, ‘period’:24, ‘npulses’:500}. If None, integration parameters are computed automatically.
- **keepAllSase** (*bool*) – Only relevant in case of sase-dedicated trains. If True, all trains are kept, else only those of the bunchPattern are kept.

#### Returns

- *xarray Dataset with TIM variables substituted by*
- *the peak caclulated values (e.g. “MCP2raw” becomes*
- *”MCP2peaks”), merged with Dataset \*merge\_with if provided.\**

`toolbox_scs.detectors.digitizers.get_laser_peaks(run, mnemonic=None, merge_with=None, bunchPattern='scs_ppl', integParams=None)`

Extracts laser photodiode signal (peak intensity) from Fast ADC digitizer. Sources can be loaded on the fly via the mnemonics argument, and/or processed from an existing data set (merge\_with). The PP laser bunch pattern is used to assign the pulse idcoordinates.

#### Parameters

- **run** (*extra\_data.DataCollection*) – DataCollection containing the digitizer data.
- **mnemonic** (*str*) – mnemonic for FastADC corresponding to laser signal, e.g. “FastADC2peaks” or ‘IO\_ILHraw’.
- **merge\_with** (*xarray Dataset*) – If provided, the resulting Dataset will be merged with this one. The FastADC variables of merge\_with (if any) will also be computed and merged.
- **bunchPattern** (*str*) – ‘sase1’ or ‘sase3’ or ‘scs\_ppl’, bunch pattern used to extract peaks.
- **integParams** (*dict*) – dictionary for raw trace integration, e.g. {‘pulseStart’:100, ‘pulsestop’:200, ‘baseStart’:50, ‘baseStop’:99, ‘period’:24, ‘npulses’:500}. If None, integration parameters are computed automatically.

#### Returns

- *xarray Dataset with all Fast ADC variables substituted by*
- *the peak caclulated values (e.g. “FastADC2raw” becomes*
- *”FastADC2peaks”).*

`toolbox_scs.detectors.digitizers.get_digitizer_peaks(run, mnemonic, merge_with=None, bunchPattern='sase3', integParams=None, keepAllSase=False)`

Automatically computes digitizer peaks. A source can be loaded on the fly via the mnemonic argument, or processed from an existing data set (merge\_with). The bunch pattern table is used to assign the pulse id coordinates.

#### Parameters

- **run** (*extra\_data.DataCollection*) – DataCollection containing the digitizer data.
- **mnemonic** (*str*) – mnemonic for FastADC or ADQ412, e.g. “IO\_ILHraw” or “MCP3apd”. The data is either loaded from the DataCollection or taken from merge\_with.

- **merge\_with** (*xarray Dataset*) – If provided, the resulting Dataset will be merged with this one.
- **bunchPattern** (*str or dict*) – ‘sase1’ or ‘sase3’ or ‘scs\_ppl’, ‘None’: bunch pattern
- **integParams** (*dict*) – dictionary for raw trace integration, e.g. {‘pulseStart’:100, ‘pulsestop’:200, ‘baseStart’:50, ‘baseStop’:99, ‘period’:24, ‘npulses’:500}. If None, integration parameters are computed automatically.
- **keepAllSase** (*bool*) – Only relevant in case of sase-dedicated trains. If True, all trains are kept, else only those of the bunchPattern are kept.

### Returns

- *xarray Dataset with digitizer peak variables. Raw variables are*
- *substituted by the peak calculated values (e.g. “FastADC2raw” becomes*
- *”FastADC2peaks”).*

`toolbox_scs.detectors.digitizers.digitizer_signal_description(run, digitizer=None)`

Check for the existence of signal description and return all corresponding channels in a dictionary.

### Parameters

- **run** (*extra\_data.DataCollection*) – DataCollection containing the digitizer data.
- **digitizer** (*str or list of str (default=None)*) – Name of the digitizer: one in [‘FastADC’, ‘FastADC2’, ‘ADQ412’, ‘ADQ412\_2’] If None, all digitizers are used

### Returns

**signal\_description** – the digitizer channels.

### Return type

dictionary containing the signal description of

## Example

```
import toolbox_scs as tb
run = tb.open_run(3481, 100)
signals = tb.digitizer_signal_description(run)
signals_fadc2 = tb.digitizer_signal_description(run, 'FastADC2')
```

## `toolbox_scs.detectors.dssc`

DSSC-detector class module

The dssc detector class. It represents a namespace for frequent evaluation while implicitly applying/requiring certain structure/naming conventions to its objects.

### comments:

- contributions should comply with pep8 code structure guidelines.
- Plot routines don’t fit into objects since they are rather fluent. They have been outsourced to `dssc_plot.py`. They can now be accessed as `toolbox_scs` member functions.

---

## Module Contents

### Classes

---

*DSSCBinner*

---

*DSSCFormatter*

---

```
class toolbox_scs.detectors.dssc.DSSCBinner(proposal_nr, run_nr, bidders={}, xgm_name='SCS_SA3',
                                             tim_names=['MCP1apd', 'MCP2apd', 'MCP3apd'],
                                             dssc_coords_stride=2)
```

```
__del__()
```

```
add_binner(name, binner)
```

Add additional binner to internal dictionary

#### Parameters

- **name** (*str*) – name of binner to be created
- **binner** (*xarray.DataArray*) – An array that represents a map how the respective coordinate should be binned.

#### Raises

***ToolBoxValueError*** – Exception: Raises exception in case the name does not correspond to a valid binner name. To be generalized.

```
load_xgm()
```

load xgm data and construct coordinate array according to corresponding dssc frame number.

```
load_tim()
```

load tim data and construct coordinate array according to corresponding dssc frame number.

```
create_pulsemask(use_data='xgm', threshold=(0, np.inf))
```

creates a mask for dssc frames according to measured xgm intensity. Once such a mask has been constructed, it will be used in the data reduction process to drop out-of-bounds pulses.

```
get_info()
```

Returns the expected shape of the binned dataset, in case bidders have been defined.

```
_bin_metadata(data)
```

```
get_xgm_binned()
```

Bin the xgm data according to the bidders of the dssc data. The result can eventually be merged into the final dataset by the DSSCFormatter.

#### Returns

**xgm\_data** – xarray dataset containing the binned xgm data

#### Return type

xarray.DataSet

```
get_tim_binned()
```

Bin the tim data according to the bidders of the dssc data. The result can eventually be merged into the final dataset by the DSSCFormatter.

**Returns**

**tim\_data** – xarray dataset containing the binned tim data

**Return type**

xarray.DataSet

**process\_data**(*modules=[]*, *filepath='./*', *chunksize=512*, *backend='loky'*, *n\_jobs=None*, *dark\_image=None*, *xgm\_normalization=False*, *normevery=1*)

Load and bin dssc data according to self.bins. No data is returned by this method. The condensed data is written to file by the worker processes directly.

**Parameters**

- **modules** (*list of ints*) – a list containing the module numbers that should be processed. If empty, all modules are processed.
- **filepath** (*str*) – the path where the files containing the reduced data should be stored.
- **chunksize** (*int*) – The number of trains that should be read in one iterative step.
- **backend** (*str*) – joblib multiprocessing backend to be used. At the moment it can be any of joblibs standard backends: ‘loky’ (default), ‘multiprocessing’, ‘threading’. Anything else than the default is experimental and not appropriately implemented in the dbdet member function ‘bin\_data’.
- **n\_jobs** (*int*) – inversely proportional of the number of cpu’s available for one job. Tasks within one job can grab a maximum of n\_CPU\_tot/n\_jobs of cpu’s. Note that when using the default backend there is no need to adjust this parameter with the current implementation.
- **dark\_image** (*xarray.DataArray*) – DataArray with dimensions compatible with the loaded dssc data. If given, it will be subtracted from the dssc data before the binning. The dark image needs to be of dimension module, trainId, pulse, x and y.
- **xgm\_normalization** (*boolean*) – if true, the dssc data is normalized by the xgm data before the binning.
- **normevery** (*int*) – integer indicating which out of normevery frame will be normalized.

**class** toolbox\_scs.detectors.dssc.DSSCFormatter(*filepath*)

**combine\_files**(*filenames=[]*)

Read the files given in filenames, and store the data in the class variable ‘data’. If no filenames are given, it tries to read the files stored in the class-internal variable ‘\_filenames’.

**Parameters**

**filenames** (*list*) – list of strings containing the names of the files to be combined.

**add\_dataArray**(*groups=[]*)

Reads additional xarray-data from the first file given in the list of filenames. This assumes that all the files in the folder contain the same additional data. To be generalized.

**Parameters**

**groups** (*list*) – list of strings with the names of the groups in the h5 file, containing additional xarray data.

**add\_attributes**(*attributes={}*)

Add additional information, such as run-type, as attributes to the formatted .h5 file.

**Parameters**

**attributes** (*dictionary*) – a dictionary, containing information or data of any kind, that will be added to the formatted .h5 file as attributes.



**save\_formatted\_data**(*filename*)

Create a .h5 file containing the main dataset in the group called 'data'. Additional groups will be created for the content of the variable 'data\_array'. Metadata about the file is added in the form of attributes.

**Parameters**

**filename** (*str*) – the name of the file to be created

`toolbox_scs.detectors.dssc_data`

**Module Contents****Functions**

<code>save_xarray</code> ( <i>fname</i> , <i>data</i> [, <i>group</i> , <i>mode</i> ])	Store xarray Dataset in the specified location
<code>save_attributes_h5</code> ( <i>fname</i> [, <i>data</i> ])	Adding attributes to a hdf5 file. This function is intended to be used to
<code>load_xarray</code> ( <i>fname</i> [, <i>group</i> , <i>form</i> ])	Load stored xarray Dataset.
<code>get_data_formatted</code> ( <i>filenames</i> , <i>data_list</i> )	Combines the given data into one dataset. For any of extra_data's data

`toolbox_scs.detectors.dssc_data.save_xarray`(*fname*, *data*, *group*='data', *mode*='a')

Store xarray Dataset in the specified location

**Parameters**

- **data** (*xarray.DataSet*) – The data to be stored
- **fname** (*str*, *int*) – filename
- **overwrite** (*bool*) – overwrite existing data

**Raises**

**ToolBoxFileError** – Exception: File existed, but overwrite was set to False.

`toolbox_scs.detectors.dssc_data.save_attributes_h5`(*fname*, *data*={})

Adding attributes to a hdf5 file. This function is intended to be used to attach metadata to a processed run.

**Parameters**

- **fname** (*str*) – filename as string
- **data** (*dictionary*) – the data that should be added to the file in form of a dictionary.

`toolbox_scs.detectors.dssc_data.load_xarray`(*fname*, *group*='data', *form*='dataset')

Load stored xarray Dataset. Comment: This function exists because of a problem with the standard netcdf engine that is malfunctioning due to related software installed in the exfel-python environment. May be dropped at some point.

**Parameters**

- **fname** (*str*) – filename as string
- **group** (*str*) – the name of the xarray dataset (group in h5 file).
- **form** (*str*) – specify whether the data to be loaded is a 'dataset' or a 'array'.

`toolbox_scs.detectors.dssc_data.get_data_formatted(filenamees=[], data_list=[])`

Combines the given data into one dataset. For any of extra\_data's data types, an xarray.Dataset is returned. The data is sorted along the 'module' dimension. The array dimension have the order 'trainId', 'pulse', 'module', 'x', 'y'. This order is required by the extra\_geometry package.

**Parameters**

- **filenames** (*list of str*) – files to be combined as a list of names. Calls '\_data\_from\_list' to actually load the data.
- **data\_list** (*list*) – list containing the already loaded data

**Returns**

**data** – A xarray.Dataset containing the combined data.

**Return type**

xarray.Dataset

`toolbox_scs.detectors.dssc_misc`

DSSC-related sub-routines.

comment: contributions should comply with pep8 code structure guidelines.

**Module Contents**

**Functions**

<code>load_dssc_info</code> (proposal, run_nr)	Loads the first data file for DSSC module 0 (this is hardcoded)
<code>create_dssc_bins</code> (name, coordinates, bins)	Creates a single entry for the dssc binner dictionary. The produced xarray
<code>get_xgm_formatted</code> (run_obj, dssc_frame_coords)	Load the xgm data and define coordinates along the pulse dimension.
<code>quickmask_DSSC_ASIC</code> (poslist)	Returns a mask for the given DSSC geometry with ASICs given in poslist
<code>load_mask</code> (fname, dssc_mask)	Load a DSSC mask file.

`toolbox_scs.detectors.dssc_misc.load_dssc_info(proposal, run_nr)`

Loads the first data file for DSSC module 0 (this is hardcoded) and returns the detector\_info dictionary

**Parameters**

- **proposal** (*str, int*) – number of proposal
- **run\_nr** (*str, int*) – number of run

**Returns**

**info** – {'dims': tuple, 'frames\_per\_train': int, 'total\_frames': int}

**Return type**

dictionary

`toolbox_scs.detectors.dssc_misc.create_dssc_bins(name, coordinates, bins)`

Creates a single entry for the dssc binner dictionary. The produced xarray data-array will later be used to perform grouping operations according to the given bins.

#### Parameters

- **name** (*str*) – name of the coordinate to be binned.
- **coordinates** (*numpy.ndarray*) – the original coordinate values (1D)
- **bins** (*numpy.ndarray*) – the bins according to which the corresponding dimension should be grouped.

#### Returns

**da** – A pre-formatted `xarray.DataArray` relating the specified dimension with its bins.

#### Return type

`xarray.DataArray`

### Examples

```
>>> import toolbox_scs as tb
>>> run = tb.open_run(2212, 235, include='*DA*')
```

1.) binner along ‘pulse’ dimension. Group data into two bins. `>>> bins_pulse = ['pumped', 'unpumped'] * 10`  
`>>> binner_pulse = tb.create_dssc_bins("pulse",`  
`np.linspace(0,19,20, dtype=int), bins_pulse)`

2.) binner along ‘train’ dimension. Group data into bins corresponding to the positions of a delay stage for instance.

```
>>> bins_trainId = tb.get_array(run, 'PP800_PhaseShifter', 0.04)
>>> binner_train = tb.create_dssc_bins("trainId",
                                     run.trainIds,
                                     bins_trainId.values)
```

`toolbox_scs.detectors.dssc_misc.get_xgm_formatted(run_obj, xgm_name, dssc_frame_coords)`

Load the xgm data and define coordinates along the pulse dimension.

#### Parameters

- **run\_obj** (*extra\_data.DataCollection*) – `DataCollection` object providing access to the xgm data to be loaded
- **xgm\_name** (*str*) – valid mnemonic of a xgm source
- **dssc\_frame\_coords** (*int, list*) – defines which dssc frames should be normalized using data from the xgm.

#### Returns

**xgm** – xgm data with coordinate ‘pulse’.

#### Return type

`xarray.DataArray`

`toolbox_scs.detectors.dssc_misc.quickmask_DSSC_ASIC(poslist)`

Returns a mask for the given DSSC geometry with ASICs given in `poslist` blanked. `poslist` is a list of (module, row, column) tuples. Each module consists of 2 rows and 8 columns of individual ASICs.

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`toolbox_scs.detectors.dssc_misc.load_mask(fname, dssc_mask)`

Load a DSSC mask file.

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**Parameters**

**fname** (*str*) – string of the filename of the mask file

**Return type**

`dssc_mask`

`toolbox_scs.detectors.dssc_plot`

DSSC visualization routines

Plotting sub-routines frequently done in combination with `dssc` analysis. The initial code is based on: [https://github.com/dscran/dssc\\_process/blob/master/example\\_image\\_process\\_pulsemask.ipynb](https://github.com/dscran/dssc_process/blob/master/example_image_process_pulsemask.ipynb)

Todo: For visualization of statistical information we could eventually switch to `seaborn`: <https://seaborn.pydata.org/>

## Module Contents

### Functions

---

`plot_xgm_threshold(xgm[, xgm_min, xgm_max, run_nr, ...])`

---

`plot_binner(binner[, yname, xname, run_nr])`

---

`plot_binner_hist(binner[, dname, run_nr])`

---

`plot_hist_processed(hist_data)`

---

`toolbox_scs.detectors.dssc_plot.plot_xgm_threshold(xgm, xgm_min=None, xgm_max=None, run_nr="", safe_fig=False)`

`toolbox_scs.detectors.dssc_plot.plot_binner(binner, yname='data', xname='data', run_nr="")`

`toolbox_scs.detectors.dssc_plot.plot_binner_hist(binner, dname='data', run_nr="")`

`toolbox_scs.detectors.dssc_plot.plot_hist_processed(hist_data)`

## toolbox\_scs.detectors.dssc\_processing

DSSC-related sub-routines.

comment: contributions should comply with pep8 code structure guidelines.

### Module Contents

#### Functions

---

`process_dssc_data`(proposal, run\_nr, module, Collects and reduces DSSC data for a single module.  
chunksize, ...)

---

`toolbox_scs.detectors.dssc_processing.process_dssc_data`(*proposal, run\_nr, module, chunksize, info, dssc\_bidders, path='.', pulsemask=None, dark\_image=None, xgm\_mnemonic='SCS\_SA3', xgm\_normalization=False, normevery=1*)

Collects and reduces DSSC data for a single module.

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#### Parameters

- **proposal** (*int*) – proposal number
- **run\_nr** (*int*) – run number
- **module** (*int*) – DSSC module to process
- **chunksize** (*int*) – number of trains to load simultaneously
- **info** (*dictionary*) – dictionary containing keys ‘dims’, ‘frames\_per\_train’, ‘total\_frames’, ‘trainIds’, ‘number\_of\_trains’.
- **dssc\_bidders** (*dictionary*) – a dictionary containing binner objects created by the Toolbox member function “create\_binner()”
- **path** (*str*) – location in which the .h5 files, containing the binned data, should be stored.
- **pulsemask** (*numpy.ndarray*) – array of booleans to be used to mask dssc data according to xgm data.
- **dark\_image** (*xarray.DataArray*) – an xarray dataarray with matching coordinates with the loaded data. If dark\_image is not None it will be subtracted from each individual dssc frame.
- **xgm\_normalization** (*bool*) – true if the data should be divided by the corresponding xgm value.
- **xgm\_mnemonic** (*str*) – Mnemonic of the xgm data to be used for normalization.
- **normevery** (*int*) – One out of normevery dssc frames will be normalized.

#### Returns

**module\_data** – xarray datastructure containing data binned according to bins.

#### Return type

xarray.Dataset

`toolbox_scs.detectors.fccd`

### Module Contents

#### Classes

---

*FastCCD*

---

#### Functions

---

*process\_one\_module(job)*

---

**class** `toolbox_scs.detectors.fccd.FastCCD`(*proposal, distance=1, raw=False*)

`__del__`()

`open_run`(*run\_nr, isDark=False, t0=0.0*)

Open a run with extra-data and prepare the virtual dataset for multiprocessing

**inputs:**

`run_nr`: the run number `isDark`: True if the run is a dark run `t0`: optional `t0` in mm

`load_gain`(*fname*)

Load a gain map by giving the filename

`collect_fastccd_file`()

Collect the raw fastCCD h5 files.

`define_scan`(*vname, bins*)

Prepare the binning of the FastCCD data.

**inputs:**

**`vname`**: variable name for the scan, can be a mnemonic string from **ToolBox** or a dictionary with ['source', 'key'] fields

`bins`: step size (or `bins_edge` but not yet implemented)

`plot_scan`()

Plot a previously defined scan to see the scan range and the statistics.

`plot_xgm_hist`(*nbins=100*)

Plots an histogram of the SCS XGM dedicated SAS3 data.

**inputs:**

`nbins`: number of the bins for the histogram.

`xgm_filter`(*xgm\_low=-np.inf, xgm\_high=np.inf*)

Filters the data by train. If one pulse within a train has an SASE3 SCS XGM value below `xgm_low` or above `xgm_high`, that train will be dropped from the dataset.

**inputs:**

`xgm_low`: low threshold value `xgm_high`: high threshold value

**load\_mask**(*fname*, *plot=True*)

Load a FastCCD mask file.

**input:**

*fname*: string of the filename of the mask file *plot*: if True, the loaded mask is plotted

**binning**()

Bin the FastCCD data by the predefined scan type (FastCCD.define()) using multiprocessing

**save**(*save\_folder=None*, *overwrite=False*)

Save the crunched data.

**inputs:**

*save\_folder*: string of the folder where to save the data. *overwrite*: boolean whether or not to overwrite existing files.

**load\_binned**(*runNB*, *dark\_runNB=None*, *xgm\_norm=True*, *save\_folder=None*)

load previously binned (crunched) FastCCD data by FastCCD.crunch() and FastCCD.save()

**inputs:**

*runNB*: run number to load *dark\_runNB*: run number of the corresponding dark *xgm\_norm*: normalize by XGM data if True *save\_folder*: path string where the crunched data are saved

**plot\_FastCCD**(*use\_mask=True*, *p\_low=1*, *p\_high=98*, *vmin=None*, *vmax=None*)

Plot pumped and unpumped FastCCD images.

**inputs:**

*use\_mask*: if True, a mask is applied on the FastCCD. *p\_low*: low percentile value to adjust the contrast scale on the unpumped and pumped image *p\_high*: high percentile value to adjust the contrast scale on the unpumped and pumped image *vmin*: low value of the image scale *vmax*: high value of the image scale

**azimuthal\_int**(*wl*, *center=None*, *angle\_range=[0, 180 - 1e-06]*, *dr=1*, *use\_mask=True*)

Perform azimuthal integration of 1D binned FastCCD run.

**inputs:**

*wl*: photon wavelength *center*: center of integration *angle\_range*: angles of integration *dr*: *dr* *use\_mask*: if True, use the loaded mask

**plot\_azimuthal\_int**(*kind='difference'*, *lim=None*)

Plot a computed azimuthal integration.

**inputs:**

*kind*: (str) either 'difference' or 'relative' to change the type of plot.

**plot\_azimuthal\_line\_cut**(*data*, *qranges*, *qwidths*)

Plot line scans on top of the data.

**inputs:**

*data*: an azimuthal integrated xarray DataArray with 'delta\_q (1/nm)' as one of its dimension. *qranges*: a list of q-range *qwidth*: a list of q-width, same length as *qranges*

`toolbox_scs.detectors.fccd.process_one_module`(*job*)

### `toolbox_scs.detectors.gotthard2`

Gotthard-II detector related sub-routines

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(contributions preferably comply with pep8 code structure guidelines.)

### Module Contents

#### Functions

---

<code>extract_GH2(ds, run[, firstFrame, bunchPattern, gh2_dim])</code>	Select and align the frames of the Gotthard-II that have been exposed
--	---

---

`toolbox_scs.detectors.gotthard2.extract_GH2(ds, run, firstFrame=0, bunchPattern='scs_pp1', gh2_dim='gh2_pId')`

Select and align the frames of the Gotthard-II that have been exposed to light.

#### Parameters

- **ds** (*xarray.Dataset*) – The dataset containing GH2 data
- **run** (*extra\_data.DataCollection*) – The run containing the bunch pattern source
- **firstFrame** (*int*) – The GH2 frame number corresponding to the first pulse of the train.
- **bunchPattern** (*str in ['scs\_pp1', 'sase3']*) – the bunch pattern used to align data. For 'scs\_pp1', the gh2\_pId dimension is renamed 'ol\_pId', and for 'sase3' gh2\_pId is renamed 'sa3\_pId'.
- **gh2\_dim** (*str*) – The name of the dimension that corresponds to the Gotthard-II frames.

#### Returns

**nds** – The aligned and reduced dataset with only-data-containing GH2 variables.

#### Return type

*xarray Dataset*

### `toolbox_scs.detectors.hrixs`

### Module Contents

#### Classes

---

<code>hRIXS</code>	The hRIXS analysis, especially curvature correction
<code>MaranaX</code>	A spin-off of the hRIXS class: with parallelized centroiding

---

`class toolbox_scs.detectors.hrixs.hRIXS(proposalNB, detector='MaranaX')`

The hRIXS analysis, especially curvature correction

The objects of this class contain the meta-information about the settings of the spectrometer, not the actual data, except possibly a dark image for background subtraction.



The actual data is loaded into `xarray`s`, and stays there.

**PROPOSAL**

the number of the proposal

**Type**  
int

**DETECTOR**

the detector to be used. Can be ['hRIXS\_det', 'MaranaX'] defaults to 'hRIXS\_det' for backward-compatibility.

**Type**  
str

**X\_RANGE**

the slice to take in the dispersive direction, in pixels. Defaults to the entire width.

**Type**  
slice

**Y\_RANGE**

the slice to take in the energy direction

**Type**  
slice

**THRESHOLD**

pixel counts above which a hit candidate is assumed, for centroiding. use None if you want to give it in standard deviations instead.

**Type**  
float

**STD\_THRESHOLD**

same as THRESHOLD, in standard deviations.

**DBL\_THRESHOLD**

threshold controlling whether a detected hit is considered to be a double hit.

**BINS**

the number of bins used in centroiding

**Type**  
int

**CURVE\_A, CURVE\_B**

the coefficients of the parabola for the curvature correction

**Type**  
float

**USE\_DARK**

whether to do dark subtraction. Is initially *False*, magically switches to *True* if a dark has been loaded, but may be reset.

**Type**  
bool

**ENERGY\_INTERCEPT, ENERGY\_SLOPE**

The calibration from pixel to energy

**FIELDS**

the fields to be loaded from the data. Add additional fields if so desired.

**Example**

```
proposal = 3145 h = hRIXS(proposal) h.Y_RANGE = slice(700, 900) h.CURVE_B = -3.695346575286939e-07
h.CURVE_A = 0.024084479232443695 h.ENERGY_SLOPE = 0.018387 h.ENERGY_INTERCEPT = 498.27
h.STD_THRESHOLD = 3.5
```

**DETECTOR\_FIELDS****aggregators**

```
set_params(**params)
```

```
get_params(*params)
```

```
from_run(runNB, proposal=None, extra_fields=(), drop_first=False, subset=None)
```

load a run

Load the run *runNB*. A thin wrapper around *toolbox.load*. :param drop\_first: if True, the first image in the run is removed from the dataset. :type drop\_first: bool

**Example**

```
data = h.from_run(145) # load run 145
```

```
data1 = h.from_run(145) # load run 145 data2 = h.from_run(155) # load run 155 data = xarray.concat([data1, data2], 'trainId') # combine both
```

```
load_dark(runNB, proposal=None)
```

load a dark run

Load the dark run *runNB* from *proposal*. The latter defaults to the current proposal. The dark is stored in this *hRIXS* object, and subsequent analyses use it for background subtraction.

**Example**

```
h.load_dark(166) # load dark run 166
```

```
find_curvature(runNB, proposal=None, plot=True, args=None, **kwargs)
```

find the curvature correction coefficients

The *hRIXS* has some aberrations which leads to the spectroscopic lines being curved on the detector. We approximate these aberrations with a parabola for later correction.

Load a run and determine the curvature. The curvature is set in *self*, and returned as a pair of floats.

**Parameters**

- **runNB** (*int*) – the run number to use
- **proposal** (*int*) – the proposal to use, default to the current proposal
- **plot** (*bool*) – whether to plot the found curvature onto the data

- **args** (*pair of float, optional*) – a starting value to prime the fitting routine

### Example

```
h.find_curvature(155) # use run 155 to fit the curvature
```

#### **centroid\_one**(*image*)

find the position of photons with sub-pixel precision

A photon is supposed to have hit the detector if the intensity within a 2-by-2 square exceeds a threshold. In this case the position of the photon is calculated as the center-of-mass in a 4-by-4 square.

Return the list of x, y coordinate pairs, corrected by the curvature.

#### **centroid\_two**(*image, energy*)

determine position of photon hits on detector

The algorithm is taken from the ESRF RIXS toolbox. The thresholds for determining photon hits are given by the incident photon energy

The function returns arrays containing the single and double hits as x and y coordinates

#### **centroid**(*data, bins=None, method='auto'*)

calculate a spectrum by finding the centroid of individual photons

This takes the *xarray.Dataset data* and returns a copy of it, with a new *xarray.DataArray* named *spectrum* added, which contains the energy spectrum calculated for each hRIXS image.

Added a key for switching between algorithms choices are “auto” and “manual” which selects for method for determining whether thresholds there is a photon hit. It changes whether *centroid\_one* or *centroid\_two* is used.

### Example

```
h.centroid(data) # find photons in all images of the run
data.spectrum[0, :].plot() # plot the spectrum of the first image
```

#### **parabola**(*x*)

#### **integrate**(*data*)

calculate a spectrum by integration

This takes the *xarray data* and returns a copy of it, with a new *dataarray* named *spectrum* added, which contains the energy spectrum calculated for each hRIXS image.

First the energy that corresponds to each pixel is calculated. Then all pixels within an energy range are summed, where the intensity of one pixel is distributed among the two energy ranges the pixel spans, proportionally to the overlap between the pixel and bin energy ranges.

The resulting data is normalized to one pixel, so the average intensity that arrived on one pixel.

### Example

```
h.integrate(data) # create spectrum by summing pixels data.spectrum[0, :].plot() # plot the spectrum of the first image
```

**aggregator**(*da, dim*)

**aggregate**(*ds, var=None, dim='trainId'*)

aggregate (i.e. mostly sum) all data within one dataset

take all images in a dataset and aggregate them and their metadata. For images, spectra and normalizations that means adding them, for others (e.g. delays) adding would not make sense, so we treat them properly. The aggregation functions of each variable are defined in the aggregators attribute of the class. If *var* is specified, group the dataset by *var* prior to aggregation. A new variable “counts” gives the number of frames aggregated in each group.

#### Parameters

- **ds** (*xarray Dataset*) – the dataset containing RIXS data
- **var** (*string*) – One of the variables in the dataset. If *var* is specified, the dataset is grouped by *var* prior to aggregation. This is useful for sorting e.g. a dataset that contains multiple delays.
- **dim** (*string*) – the dimension over which to aggregate the data

### Example

```
h.centroid(data) # create spectra from finding photons agg = h.aggregate(data) # sum all spectra
agg.spectrum.plot() # plot the resulting spectrum
```

```
agg2 = h.aggregate(data, 'hRIXS_delay') # group data by delay agg2.spectrum[0, :].plot() # plot the spectrum for first value
```

**aggregate\_ds**(*ds, dim='trainId'*)

**normalize**(*data, which='hRIXS\_norm'*)

Adds a ‘normalized’ variable to the dataset defined as the ration between ‘spectrum’ and ‘which’

#### Parameters

- **data** (*xarray Dataset*) – the dataset containing hRIXS data
- **which** (*string, default="hRIXS\_norm"*) – one of the variables of the dataset, usually “hRIXS\_norm” or “counts”

**class** toolbox\_scs.detectors.hrixs.**MaranaX**(\*args, \*\*kwargs)

Bases: *hRIXS*

A spin-off of the hRIXS class: with parallelized centroiding

**NUM\_MAX\_HITS** = 30

**centroid**(*data, bins=None, \*\*kwargs*)

calculate a spectrum by finding the centroid of individual photons

This takes the *xarray.Dataset data* and returns a copy of it, with a new *xarray.DataArray* named *spectrum* added, which contains the energy spectrum calculated for each hRIXS image.

Added a key for switching between algorithms choices are “auto” and “manual” which selects for method for determining whether thresholds there is a photon hit. It changes whether *centroid\_one* or *centroid\_two* is used.

## Example

```

h.centroid(data) # find photons in all images of the run data.spectrum[0, :].plot() # plot the spectrum of the
first image

_centroid_tb_map(_, index, data)

_centroid_map(index, *, image, energy)

_centroid_task(index, image, energy)

_histogram_task(index, total, double, default_range)

centroid_from_run(runNB, proposal=None, extra_fields=(), drop_first=False, subset=None, bins=None,
return_hits=False)

    A combined function of from_run() and centroid(), which uses extra_data and pasha to avoid bulk loading
of files.

_centroid_ed_map(_, index, trainId, data)

static _mnemo_to_prop(mnemo)

_is_mnemo_in_run(mnemo, run)

```

## toolbox\_scs.detectors.pes

Beam Arrival Monitor related sub-routines

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(contributions preferably comply with pep8 code structure guidelines.)

## Module Contents

### Functions

<code>get_pes_tof</code> (proposal, runNB, mnemonic[, start, ...])	Extracts time-of-flight spectra from raw digitizer traces. The spectra
<code>get_pes_params</code> (run[, channel])	Extract PES parameters for a given <i>extra_data</i> DataCollection.
<code>save_pes_avg_traces</code> (proposal, runNB[, channels, subdir])	Save average traces of PES into an h5 file.
<code>load_pes_avg_traces</code> (proposal, runNB[, channels, subdir])	Load existing PES average traces.

```

toolbox_scs.detectors.pes.get_pes_tof(proposal, runNB, mnemonic, start=0, origin=None, width=None,
subtract_baseline=False, baseStart=None, baseWidth=40,
merge_with=None)

```

Extracts time-of-flight spectra from raw digitizer traces. The spectra are aligned by pulse Id using the SASE 3 bunch pattern. If *origin* is not *None*, a time coordinate in nanoseconds 'time\_ns' is computed and added to the *DataArray*.

### Parameters

- **proposal** (*int*) – The proposal number.
- **runNB** (*int*) – The run number.
- **mnemonic** (*str*) – mnemonic for PES, e.g. “PES\_2Araw”.
- **start** (*int*) – starting sample of the first spectrum in the raw trace.
- **origin** (*int*) – sample of the trace that corresponds to time-of-flight origin, also called prompt. Used to compute the ‘time\_ns’ coordinates. If None, computation of ‘time\_ns’ is skipped.
- **width** (*int*) – number of samples per spectra. If None, the number of samples for 4.5 MHz repetition rate is used.
- **subtract\_baseline** (*bool*) – If True, subtract baseline defined by baseStart and baseWidth to each spectrum.
- **baseStart** (*int*) – starting sample of the baseline.
- **baseWidth** (*int*) – number of samples to average (starting from baseStart) for baseline calculation.
- **merge\_with** (*xarray Dataset*) – If provided, the resulting Dataset will be merged with this one.

**Returns**

**pes** – DataArray containing the PES time-of-flight spectra.

**Return type**

xarray DataArray

**Example**

```
>>> import toolbox_scs as tb
>>> import toolbox_scs.detectors as tbdet
>>> proposal, runNB = 900447, 12
>>> pes = tbdet.get_pes_tof(proposal, runNB, 'PES_2Araw',
>>>                          start=2557, origin=76)
```

`toolbox_scs.detectors.pes.get_pes_params(run, channel=None)`

Extract PES parameters for a given extra\_data DataCollection. Parameters are gas, binding energy, retardation voltages or all voltages of the MPOD.

**Parameters**

- **run** (*extra\_data.DataCollection*) – DataCollection containing the digitizer data
- **channel** (*str*) – Channel name or PES mnemonic, e.g. ‘2A’ or ‘PES\_1Craw’. If None, or if the channel is not found in the data, the retardation voltage for all channels is retrieved.

**Returns**

**params** – dictionary of PES parameters

**Return type**

dict

`toolbox_scs.detectors.pes.save_pes_avg_traces(proposal, runNB, channels=None,
 subdir='usr/processed_runs')`

Save average traces of PES into an h5 file.

**Parameters**

- **proposal** (*int*) – The proposal number.
- **runNB** (*int*) – The run number.
- **channels** (*str or list*) – The PES channels or mnemonics, e.g. ‘2A’, [‘2A’, ‘3C’], [‘PES\_1Araw’, ‘PES\_4Draw’, ‘3B’]
- **subdir** (*str*) – subdirectory. The data is stored in <proposal path>/<subdir>/r{runNB:04d}/f{r{runNB:04d}}-pes-data.h5’
- **Output** –
- -----
- **traces.** (*xarray Dataset saved in a h5 file containing the PES average*)
- 

`toolbox_scs.detectors.pes.load_pes_avg_traces`(*proposal, runNB, channels=None, subdir='usr/processed\_runs'*)

Load existing PES average traces.

**Parameters**

- **proposal** (*int*) – The proposal number.
- **runNB** (*int*) – The run number.
- **channels** (*str or list*) – The PES channels or mnemonics, e.g. ‘2A’, [‘2A’, ‘3C’], [‘PES\_1Araw’, ‘PES\_4Draw’, ‘3B’]
- **subdir** (*str*) – subdirectory. The data is stored in <proposal path>/<subdir>/r{runNB:04d}/f{r{runNB:04d}}-pes-data.h5’
- **Output** –
- -----
- **ds** (*xarray Dataset*) – dataset containing the PES average traces.

`toolbox_scs.detectors.viking`

**Module Contents****Classes**


---

*Viking*

The Viking analysis (spectrometer used in combination with Andor Newton)

---

**class** `toolbox_scs.detectors.viking.Viking`(*proposalNB*)

The Viking analysis (spectrometer used in combination with Andor Newton camera)

The objects of this class contain the meta-information about the settings of the spectrometer, not the actual data, except possibly a dark image for background subtraction.

The actual data is loaded into *xarray*’s via the method `from_run()`, and stays there.

### PROPOSAL

the number of the proposal

**Type**  
int

### X\_RANGE

the slice to take in the non-dispersive direction, in pixels. Defaults to the entire width.

**Type**  
slice

### Y\_RANGE

the slice to take in the energy dispersive direction

**Type**  
slice

### USE\_DARK

whether to do dark subtraction. Is initially *False*, magically switches to *True* if a dark has been loaded, but may be reset.

**Type**  
bool

### ENERGY\_CALIB

The 2nd degree polynomial coefficients for calibration from pixel to energy. Defaults to [0, 1, 0] (no calibration applied).

**Type**  
1D array (len=3)

### BL\_POLY\_DEG

the degree of the polynomial used for baseline subtraction. Defaults to 1.

**Type**  
int

### BL\_SIGNAL\_RANGE

the dispersive-axis range, defined by an interval [min, max], to avoid when fitting a polynomial for baseline subtraction. Multiple ranges can be provided in the form [[min1, max1], [min2, max2], ...].

**Type**  
list

### FIELDS

the fields to be loaded from the data. Add additional fields if so desired.

**Type**  
list of str



### Example

```
proposal = 2953 v = Viking(proposal) v.X_RANGE = slice(0, 1900) v.Y_RANGE = slice(38, 80)
v.ENERGY_CALIB = [1.47802667e-06, 2.30600328e-02, 5.15884589e+02] v.BL_SIGNAL_RANGE = [500,
545]
```

```
set_params(**params)
```

```
get_params(*params)
```

```
from_run(runNB, add_attrs=True)
```

load a run

Load the run *runNB*. A thin wrapper around *toolbox\_scs.load*.

#### Parameters

- **runNB** (*int*) – the run number
- **add\_attrs** (*bool*) – if True, adds the camera parameters as attributes to the dataset (see `get_camera_params()`)
- **Output** –
- -----
- **ds** (*xarray Dataset*) – the dataset containing the camera images

### Example

```
data = v.from_run(145) # load run 145
```

```
data1 = v.from_run(145) # load run 145 data2 = v.from_run(155) # load run 155
data = xarray.concat([data1, data2], 'trainId') # combine both
```

```
load_dark(runNB=None)
```

```
integrate(data)
```

This function calculates the mean over the non-dispersive dimension to create a spectrum. If the camera parameters are known, the spectrum is multiplied by the number of photoelectrons per ADC count. A new variable “spectrum” is added to the data.

```
get_camera_gain(run)
```

Get the preamp gain of the camera in the Viking spectrometer for a specified run.

#### Parameters

- **run** (*extra\_data DataCollection*) – information on the run
- **Output** –
- -----
- **gain** (*int*) –

```
e_per_counts(run, gain=None)
```

Conversion factor from camera digital counts to photoelectrons per count. The values can be found in the camera datasheet (Andor Newton) but they have been slightly corrected for High Sensitivity mode after analysis of runs 1204, 1207 and 1208, proposal 2937.

#### Parameters

- **run** (*extra\_data DataCollection*) – information on the run

- **gain** (*int*) – the camera preamp gain
- **Output** –
- -----
- **ret** (*float*) – photoelectrons per count

**get\_camera\_params**(*run*)

**removePolyBaseline**(*data*)

Removes a polynomial baseline to a spectrum, assuming a fixed position for the signal.

#### Parameters

- **data** (*xarray Dataset*) – The Viking data containing the variable “spectrum”
- **Output** –
- -----
- **data** – the original dataset with the added variable “spectrum\_nobl” containing the baseline subtracted spectra.

**xas**(*data, data\_ref, thickness=1, plot=False, plot\_errors=True, xas\_ylim=(-1, 3)*)

Given two independent datasets (one with sample and one reference), this calculates the average XAS spectrum (absorption coefficient), associated standard deviation and standard error. The absorption coefficient is defined as  $-\log(I_t/I_0)/\text{thickness}$ .

#### Parameters

- **data** (*xarray Dataset*) – the dataset containing the spectra with sample
- **data\_ref** (*xarray Dataset*) – the dataset containing the spectra without sample
- **thickness** (*float*) – the thickness used for the calculation of the absorption coefficient
- **plot** (*bool*) – If True, plot the resulting average spectra.
- **plot\_errors** (*bool*) – If True, adds the 95% confidence interval on the spectra.
- **xas\_ylim** (*tuple or list of float*) – the y limits for the XAS plot.
- **Output** –
- -----
- **xas** (*xarray Dataset*) – the dataset containing the computed XAS quantities:  $I_0$ ,  $I_t$ ,  $\text{absorptionCoef}$  and their associated errors.

**calibrate**(*runList, plot=True*)

This routine determines the calibration coefficients to translate the camera pixels into energy in eV. The Viking spectrometer is calibrated using the beamline monochromator: runs with various monochromatized photon energy are recorded and their peak position on the detector are determined by Gaussian fitting. The energy vs. position data is then fitted to a second degree polynomial.

#### Parameters

- **runList** (*list of int*) – the list of runs containing the monochromatized spectra
- **plot** (*bool*) – if True, the spectra, their Gaussian fits and the calibration curve are plotted.
- **Output** –
- -----
- **energy\_calib** (*np. array*) – the calibration coefficients (2nd degree polynomial)

`toolbox_scs.detectors.xgm`

XGM related sub-routines

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(contributions preferably comply with pep8 code structure guidelines.)

## Module Contents

### Functions

<code>get_xgm(run[, mnemonics, merge_with, indices])</code>	Load and/or computes XGM data. Sources can be loaded on the
<code>calibrate_xgm(run, data[, xgm, plot])</code>	Calculates the calibration factor F between the photon flux (slow signal)

`toolbox_scs.detectors.xgm.get_xgm(run, mnemonics=None, merge_with=None, indices=slice(0, None))`

Load and/or computes XGM data. Sources can be loaded on the fly via the `mnemonics` argument, or processed from an existing dataset (`merge_with`). The bunch pattern table is used to assign the pulse id coordinates if the number of pulses has changed during the run.

#### Parameters

- **run** (`extra_data.DataCollection`) – DataCollection containing the xgm data.
- **mnemonics** (`str` or `list of str`) – mnemonics for XGM, e.g. “SCS\_SA3” or [“XTD10\_XGM”, “SCS\_XGM”]. If None, defaults to “SCS\_SA3” in case no `merge_with` dataset is provided.
- **merge\_with** (`xarray Dataset`) – If provided, the resulting Dataset will be merged with this one. The XGM variables of `merge_with` (if any) will also be computed and merged.
- **indices** (`slice`, `list`, `1D array`) – Pulse indices of the XGM array in case bunch pattern is missing.

#### Returns

merged with Dataset `merge_with` if provided.

#### Return type

`xarray Dataset` with pulse-resolved XGM variables aligned,

### Example

```
>>> import toolbox_scs as tb
>>> run, ds = tb.load(2212, 213, 'SCS_SA3')
>>> ds['SCS_SA3']
```

`toolbox_scs.detectors.xgm.calibrate_xgm(run, data, xgm='SCS', plot=False)`

Calculates the calibration factor F between the photon flux (slow signal) and the fast signal (pulse-resolved) of the sase 3 pulses. The calibrated fast signal is equal to the uncalibrated one multiplied by F.

#### Parameters

- **run** (`extra_data.DataCollection`) – DataCollection containing the digitizer data.

- **data** (*xarray Dataset*) – dataset containing the pulse-resolved sase 3 signal, e.g. ‘SCS\_SA3’
- **xgm** (*str*) – one in {‘XTD10’, ‘SCS’}
- **plot** (*bool*) – If True, shows a plot of the photon flux, averaged fast signal and calibrated fast signal.

### Returns

**F** – calibration factor F defined as: calibrated XGM [microJ] = F \* fast XGM array (‘SCS\_SA3’ or ‘XTD10\_SA3’)

### Return type

float

### Example

```
>>> import toolbox_scs as tb
>>> import toolbox_scs.detectors as tbdet
>>> run, data = tb.load(900074, 69, ['SCS_XGM'])
>>> ds = tbdet.get_xgm(run, merge_with=data)
>>> F = tbdet.calibrate_xgm(run, ds, plot=True)
>>> # Add calibrated XGM to the dataset:
>>> ds['SCS_SA3_uJ'] = F * ds['SCS_SA3']
```

## Package Contents

### Classes

---

<i>AzimuthalIntegrator</i>	
<i>AzimuthalIntegratorDSSC</i>	
<i>DSSCBinner</i>	
<i>DSSCFormatter</i>	
<i>hRIXS</i>	The hRIXS analysis, especially curvature correction
<i>MaranaX</i>	A spin-off of the hRIXS class: with parallelized centroiding
<i>Viking</i>	The Viking analysis (spectrometer used in combination with Andor Newton)

---

## Functions

<i>get_bam</i> (run[, mnemonics, merge_with, bunchPattern, ...])	Load beam arrival monitor (BAM) data and align their pulse ID
<i>get_bam_params</i> (run[, mnemo_or_source])	Extract the run values of bamStatus[1-3] and bamError.
<i>check_peak_params</i> (run, mnemonic[, raw_trace, ntrains, ...])	Checks and plots the peak parameters (pulse window and baseline window)
<i>get_digitizer_peaks</i> (run, mnemonic[, merge_with, ...])	Automatically computes digitizer peaks. A source can be loaded on the
<i>get_laser_peaks</i> (run[, mnemonic, merge_with, ...])	Extracts laser photodiode signal (peak intensity) from Fast ADC
<i>get_peaks</i> (run, data, mnemonic[, useRaw, autoFind, ...])	Extract peaks from one source (channel) of a digitizer.
<i>get_tim_peaks</i> (run[, mnemonic, merge_with, ...])	Automatically computes TIM peaks. Sources can be loaded on the
<i>digitizer_signal_description</i> (run[, digitizer])	Check for the existence of signal description and return all corresponding
<i>get_dig_avg_trace</i> (run, mnemonic[, ntrains])	Compute the average over ntrains evenly spaced across all trains
<i>get_data_formatted</i> ([filenames, data_list])	Combines the given data into one dataset. For any of extra_data's data
<i>load_xarray</i> (fname[, group, form])	Load stored xarray Dataset.
<i>save_attributes_h5</i> (fname[, data])	Adding attributes to a hdf5 file. This function is intended to be used to
<i>save_xarray</i> (fname, data[, group, mode])	Store xarray Dataset in the specified location
<i>create_dssc_bins</i> (name, coordinates, bins)	Creates a single entry for the dssc binner dictionary. The produced xarray
<i>get_xgm_formatted</i> (run_obj, xgm_name, dssc_frame_coords)	Load the xgm data and define coordinates along the pulse dimension.
<i>load_dssc_info</i> (proposal, run_nr)	Loads the first data file for DSSC module 0 (this is hard-coded)
<i>load_mask</i> (fname, dssc_mask)	Load a DSSC mask file.
<i>quickmask_DSSC_ASIC</i> (poslist)	Returns a mask for the given DSSC geometry with ASICs given in poslist
<i>process_dssc_data</i> (proposal, run_nr, module, chunksize, ...)	Collects and reduces DSSC data for a single module.
<i>extract_GH2</i> (ds, run[, firstFrame, bunchPattern, gh2_dim])	Select and align the frames of the Gotthard-II that have been exposed
<i>get_pes_params</i> (run[, channel])	Extract PES parameters for a given extra_data DataCollection.
<i>get_pes_tof</i> (proposal, runNB, mnemonic[, start, ...])	Extracts time-of-flight spectra from raw digitizer traces. The spectra
<i>save_pes_avg_traces</i> (proposal, runNB[, channels, subdir])	Save average traces of PES into an h5 file.
<i>load_pes_avg_traces</i> (proposal, runNB[, channels, subdir])	Load existing PES average traces.
<i>calibrate_xgm</i> (run, data[, xgm, plot])	Calculates the calibration factor F between the photon flux (slow signal)
<i>get_xgm</i> (run[, mnemonics, merge_with, indices])	Load and/or computes XGM data. Sources can be loaded on the

## Attributes

---

`__all__`

---

`class toolbox_scs.detectors.AzimuthalIntegrator(imageshape, center, polar_range, aspect=204 / 236, **kwargs)`

Bases: object

`_calc_dist_array(shape, center, aspect)`

Calculate pixel coordinates for the given shape.

`_calc_indices(**kwargs)`

Calculates the list of indices for the flattened image array.

`_calc_polar_mask(polar_range)`

`calc_q(distance, wavelength)`

Calculate momentum transfer coordinate.

### Parameters

- **distance** (*float*) – Sample - detector distance in meter
- **wavelength** (*float*) – wavelength of scattered light in meter

### Returns

**deltaq** – Momentum transfer coordinate in 1/m

### Return type

np.ndarray

`__call__(image)`

`class toolbox_scs.detectors.AzimuthalIntegratorDSSC(geom, polar_range, dxdy=(0, 0), **kwargs)`

Bases: *AzimuthalIntegrator*

`_calc_dist_array(geom, dxdy)`

Calculate pixel coordinates for the given shape.

`toolbox_scs.detectors.get_bam(run, mnemonics=None, merge_with=None, bunchPattern='sase3', pulseIds=None)`

Load beam arrival monitor (BAM) data and align their pulse ID according to the bunch pattern. Sources can be loaded on the fly via the mnemonics argument, or processed from an existing data set (*merge\_with*).

### Parameters

- **run** (*extra\_data.DataCollection*) – DataCollection containing the bam data.
- **mnemonics** (*str or list of str*) – mnemonics for BAM, e.g. “BAM1932M” or [“BAM414”, “BAM1932M”]. the arrays are either taken from *merge\_with* or loaded from the DataCollection run.
- **merge\_with** (*xarray Dataset*) – If provided, the resulting Dataset will be merged with this one. If *merge\_with* contains variables in *mnemonics*, they will be selected, aligned and merged.
- **bunchPattern** (*str*) – ‘sase1’ or ‘sase3’ or ‘scs\_ppl’, bunch pattern used to extract peaks. The pulse ID dimension will be named ‘sa1\_pId’, ‘sa3\_pId’ or ‘ol\_pId’, respectively.

- **pulseIds** (*list*, *1D array*) – Pulse Ids. If None, they are automatically loaded.

**Returns**

merged with Dataset *merge\_with* if provided.

**Return type**

xarray Dataset with pulse-resolved BAM variables aligned,

**Example**

```
>>> import toolbox_scs as tb
>>> run = tb.open_run(2711, 303)
>>> bam = tb.get_bam(run, 'BAM1932S')
```

`toolbox_scs.detectors.get_bam_params(run, mnemo_or_source='BAM1932S')`

Extract the run values of bamStatus[1-3] and bamError.

**Parameters**

- **run** (*extra\_data.DataCollection*) – DataCollection containing the bam data.
- **mnemo\_or\_source** (*str*) – mnemonic of the BAM, e.g. 'BAM414', or source name, e.g. 'SCS\_ILH\_LAS/DOOCS/BAM\_414\_B2'.

**Returns**

**params** – dictionary containing the extracted parameters.

**Return type**

dict

---

**Note:** The extracted parameters are run values, they do not reflect any possible change during the run.

---

`toolbox_scs.detectors.check_peak_params(run, mnemonic, raw_trace=None, ntrains=200, params=None, plot=True, show_all=False, bunchPattern='sase3')`

Checks and plots the peak parameters (pulse window and baseline window of a raw digitizer trace) used to compute the peak integration. These parameters are either set by the digitizer peak-integration settings, or are determined by a peak finding algorithm (used in `get_tim_peaks` or `get_fast_adc_peaks`) when the inputs are raw traces. The parameters can also be provided manually for visual inspection. The plot either shows the first and last pulse of the trace or the entire trace.

**Parameters**

- **run** (*extra\_data.DataCollection*) – DataCollection containing the digitizer data.
- **mnemonic** (*str*) – ToolBox mnemonic of the digitizer data, e.g. 'MCP2apd'.
- **raw\_trace** (*optional, 1D numpy array or xarray DataArray*) – Raw trace to display. If None, the average raw trace over ntrains of the corresponding channel is loaded (this can be time-consuming).
- **ntrains** (*optional, int*) – Only used if raw\_trace is None. Number of trains used to calculate the average raw trace of the corresponding channel.
- **plot** (*bool*) – If True, displays the raw trace and peak integration regions.
- **show\_all** (*bool*) – If True, displays the entire raw trace and all peak integration regions (this can be time-consuming). If False, shows the first and last pulse according to the bunchPattern.

- **bunchPattern** (*optional, str*) – Only used if plot is True. Checks the bunch pattern against the digitizer peak parameters and shows potential mismatch.

### Return type

dictionary of peak integration parameters

```
toolbox_scs.detectors.get_digitizer_peaks(run, mnemonic, merge_with=None, bunchPattern='sase3',
                                         integParams=None, keepAllSase=False)
```

Automatically computes digitizer peaks. A source can be loaded on the fly via the mnemonic argument, or processed from an existing data set (merge\_with). The bunch pattern table is used to assign the pulse id coordinates.

### Parameters

- **run** (*extra\_data.DataCollection*) – DataCollection containing the digitizer data.
- **mnemonic** (*str*) – mnemonic for FastADC or ADQ412, e.g. “IO\_ILHraw” or “MCP3apd”. The data is either loaded from the DataCollection or taken from merge\_with.
- **merge\_with** (*xarray Dataset*) – If provided, the resulting Dataset will be merged with this one.
- **bunchPattern** (*str or dict*) – ‘sase1’ or ‘sase3’ or ‘scs\_pp1’, ‘None’: bunch pattern
- **integParams** (*dict*) – dictionary for raw trace integration, e.g. {‘pulseStart’:100, ‘pulsestop’:200, ‘baseStart’:50, ‘baseStop’:99, ‘period’:24, ‘npulses’:500}. If None, integration parameters are computed automatically.
- **keepAllSase** (*bool*) – Only relevant in case of sase-dedicated trains. If True, all trains are kept, else only those of the bunchPattern are kept.

### Returns

- *xarray Dataset with digitizer peak variables. Raw variables are*
- *substituted by the peak caclulated values (e.g. “FastADC2raw” becomes*
- *”FastADC2peaks”).*

```
toolbox_scs.detectors.get_laser_peaks(run, mnemonic=None, merge_with=None, bunchPattern='scs_pp1',
                                       integParams=None)
```

Extracts laser photodiode signal (peak intensity) from Fast ADC digitizer. Sources can be loaded on the fly via the mnemonics argument, and/or processed from an existing data set (merge\_with). The PP laser bunch pattern is used to assign the pulse idcoordinates.

### Parameters

- **run** (*extra\_data.DataCollection*) – DataCollection containing the digitizer data.
- **mnemonic** (*str*) – mnemonic for FastADC corresponding to laser signal, e.g. “FastADC2peaks” or ‘IO\_ILHraw’.
- **merge\_with** (*xarray Dataset*) – If provided, the resulting Dataset will be merged with this one. The FastADC variables of merge\_with (if any) will also be computed and merged.
- **bunchPattern** (*str*) – ‘sase1’ or ‘sase3’ or ‘scs\_pp1’, bunch pattern used to extract peaks.
- **integParams** (*dict*) – dictionary for raw trace integration, e.g. {‘pulseStart’:100, ‘pulsestop’:200, ‘baseStart’:50, ‘baseStop’:99, ‘period’:24, ‘npulses’:500}. If None, integration parameters are computed automatically.

### Returns

- *xarray Dataset with all Fast ADC variables substituted by*
- *the peak caclulated values (e.g. “FastADC2raw” becomes*



- "FastADC2peaks").

`toolbox_scs.detectors.get_peaks(run, data, mnemonic, useRaw=True, autoFind=True, integParams=None, bunchPattern='sase3', bpt=None, extra_dim=None, indices=None)`

Extract peaks from one source (channel) of a digitizer.

#### Parameters

- **run** (*extra\_data.DataCollection*) – DataCollection containing the digitizer data
- **data** (*xarray DataArray* or *str*) – array containing the raw traces or peak-integrated values from the digitizer. If *str*, must be one of the ToolBox mnemonics. If *None*, the data is loaded via the source and key arguments.
- **mnemonic** (*str* or *dict*) – ToolBox mnemonic or dict with source and key as in {‘source’: ‘SCS\_UTC1\_ADQ/ADC/1:network’, ‘key’: ‘digitizers.channel\_1\_A.raw.samples’}
- **useRaw** (*bool*) – If *True*, extract peaks from raw traces. If *False*, uses the APD (or peaks) data from the digitizer.
- **autoFind** (*bool*) – If *True*, finds integration parameters by inspecting the average raw trace. Only valid if *useRaw* is *True*.
- **integParams** (*dict*) – dictionary containing the integration parameters for raw trace integration: ‘pulseStart’, ‘pulseStop’, ‘baseStart’, ‘baseStop’, ‘period’, ‘npulses’. Not used if *autoFind* is *True*. All keys are required when bunch pattern is missing.
- **bunchPattern** (*str*) – match the peaks to the bunch pattern: ‘sase1’, ‘sase3’, ‘scs\_ppl’. This will dictate the name of the pulse ID coordinates: ‘sa1\_pId’, ‘sa3\_pId’ or ‘scs\_ppl’.
- **bpt** (*xarray DataArray*) – bunch pattern table
- **extra\_dim** (*str*) – Name given to the dimension along the peaks. If *None*, the name is given according to the *bunchPattern*.
- **indices** (*array, slice*) – indices from the peak-integrated data to retrieve. Only required when bunch pattern is missing and *useRaw* is *False*.

#### Return type

*xarray.DataArray* containing digitizer peaks with pulse coordinates

`toolbox_scs.detectors.get_tim_peaks(run, mnemonic=None, merge_with=None, bunchPattern='sase3', integParams=None, keepAllSase=False)`

Automatically computes TIM peaks. Sources can be loaded on the fly via the mnemonics argument, or processed from an existing data set (*merge\_with*). The bunch pattern table is used to assign the pulse id coordinates.

#### Parameters

- **run** (*extra\_data.DataCollection*) – DataCollection containing the digitizer data.
- **mnemonic** (*str*) – mnemonics for TIM, e.g. “MCP2apd”.
- **merge\_with** (*xarray Dataset*) – If provided, the resulting Dataset will be merged with this one. The TIM variables of *merge\_with* (if any) will also be computed and merged.
- **bunchPattern** (*str*) – ‘sase1’ or ‘sase3’ or ‘scs\_ppl’, bunch pattern used to extract peaks. The pulse ID dimension will be named ‘sa1\_pId’, ‘sa3\_pId’ or ‘ol\_pId’, respectively.
- **integParams** (*dict*) – dictionary for raw trace integration, e.g. {‘pulseStart’:100, ‘pulsestop’:200, ‘baseStart’:50, ‘baseStop’:99, ‘period’:24, ‘npulses’:500}. If *None*, integration parameters are computed automatically.
- **keepAllSase** (*bool*) – Only relevant in case of sase-dedicated trains. If *True*, all trains are kept, else only those of the *bunchPattern* are kept.

**Returns**

- *xarray* Dataset with TIM variables substituted by
- the peak calculated values (e.g. “MCP2raw” becomes
- “MCP2peaks”), merged with Dataset \*merge\_with if provided.\*

`toolbox_scs.detectors.digitizer_signal_description(run, digitizer=None)`

Check for the existence of signal description and return all corresponding channels in a dictionary.

**Parameters**

- **run** (*extra\_data.DataCollection*) – DataCollection containing the digitizer data.
- **digitizer** (*str or list of str (default=None)*) – Name of the digitizer: one in ['FastADC', 'FastADC2', 'ADQ412', 'ADQ412\_2'] If None, all digitizers are used

**Returns**

**signal\_description** – the digitizer channels.

**Return type**

dictionary containing the signal description of

**Example**

```
import toolbox_scs as tb
run = tb.open_run(3481, 100)
signals = tb.digitizer_signal_description(run)
signals_fadc2 = tb.digitizer_signal_description(run, 'FastADC2')
```

`toolbox_scs.detectors.get_dig_avg_trace(run, mnemonic, ntrains=None)`

Compute the average over ntrains evenly spaced across all trains of a digitizer trace.

**Parameters**

- **run** (*extra\_data.DataCollection*) – DataCollection containing the digitizer data.
- **mnemonic** (*str*) – ToolBox mnemonic of the digitizer data, e.g. ‘MCP2apd’.
- **ntrains** (*int*) – Number of trains used to calculate the average raw trace. If None, all trains are used.

**Returns**

**trace** – The average digitizer trace

**Return type**

DataArray

```
class toolbox_scs.detectors.DSSCBinner(proposal_nr, run_nr, bidders={}, xgm_name='SCS_SA3',
                                       tim_names=['MCP1apd', 'MCP2apd', 'MCP3apd'],
                                       dssc_coords_stride=2)
```

```
__del__()
```

```
add_binner(name, binner)
```

Add additional binner to internal dictionary

**Parameters**

- **name** (*str*) – name of binner to be created
- **binner** (*xarray.DataArray*) – An array that represents a map how the respective coordinate should be binned.

**Raises**

***ToolBoxValueError*** – Exception: Raises exception in case the name does not correspond to a valid binner name. To be generalized.

**load\_xgm()**

load xgm data and construct coordinate array according to corresponding dssc frame number.

**load\_tim()**

load tim data and construct coordinate array according to corresponding dssc frame number.

**create\_pulsemask(*use\_data='xgm', threshold=(0, np.inf)*)**

creates a mask for dssc frames according to measured xgm intensity. Once such a mask has been constructed, it will be used in the data reduction process to drop out-of-bounds pulses.

**get\_info()**

Returns the expected shape of the binned dataset, in case binners have been defined.

**\_bin\_metadata(*data*)****get\_xgm\_binned()**

Bin the xgm data according to the binners of the dssc data. The result can eventually be merged into the final dataset by the DSSCFormatter.

**Returns**

**xgm\_data** – xarray dataset containing the binned xgm data

**Return type**

xarray.DataSet

**get\_tim\_binned()**

Bin the tim data according to the binners of the dssc data. The result can eventually be merged into the final dataset by the DSSCFormatter.

**Returns**

**tim\_data** – xarray dataset containing the binned tim data

**Return type**

xarray.DataSet

**process\_data(*modules=[], filepath='./', chunksize=512, backend='loky', n\_jobs=None, dark\_image=None, xgm\_normalization=False, normevery=1*)**

Load and bin dssc data according to self.bins. No data is returned by this method. The condensed data is written to file by the worker processes directly.

**Parameters**

- **modules** (*list of ints*) – a list containing the module numbers that should be processed. If empty, all modules are processed.
- **filepath** (*str*) – the path where the files containing the reduced data should be stored.
- **chunksize** (*int*) – The number of trains that should be read in one iterative step.
- **backend** (*str*) – joblib multiprocessing backend to be used. At the moment it can be any of joblibs standard backends: ‘loky’ (default), ‘multiprocessing’, ‘threading’. Anything else than the default is experimental and not appropriately implemented in the dbdet member function ‘bin\_data’.
- **n\_jobs** (*int*) – inversely proportional of the number of cpu’s available for one job. Tasks within one job can grab a maximum of  $n\_CPU\_tot/n\_jobs$  of cpu’s. Note that when using

the default backend there is no need to adjust this parameter with the current implementation.

- **dark\_image** (*xarray.DataArray*) – DataArray with dimensions compatible with the loaded dssc data. If given, it will be subtracted from the dssc data before the binning. The dark image needs to be of dimension module, trainId, pulse, x and y.
- **xgm\_normalization** (*boolean*) – if true, the dssc data is normalized by the xgm data before the binning.
- **normevery** (*int*) – integer indicating which out of normevery frame will be normalized.

**class** `toolbox_scs.detectors.DSSCFormatter`(*filepath*)

**combine\_files**(*filenames=[]*)

Read the files given in filenames, and store the data in the class variable ‘data’. If no filenames are given, it tries to read the files stored in the class-internal variable ‘\_filenames’.

**Parameters**

**filenames** (*list*) – list of strings containing the names of the files to be combined.

**add\_dataArray**(*groups=[]*)

Reads additional xarray-data from the first file given in the list of filenames. This assumes that all the files in the folder contain the same additional data. To be generalized.

**Parameters**

**groups** (*list*) – list of strings with the names of the groups in the h5 file, containing additional xarray data.

**add\_attributes**(*attributes={}*)

Add additional information, such as run-type, as attributes to the formatted .h5 file.

**Parameters**

**attributes** (*dictionary*) – a dictionary, containing information or data of any kind, that will be added to the formatted .h5 file as attributes.

**save\_formatted\_data**(*filename*)

Create a .h5 file containing the main dataset in the group called ‘data’. Additional groups will be created for the content of the variable ‘data\_array’. Metadata about the file is added in the form of attributes.

**Parameters**

**filename** (*str*) – the name of the file to be created

`toolbox_scs.detectors.get_data_formatted`(*filenames=[], data\_list=[]*)

Combines the given data into one dataset. For any of extra\_data’s data types, an xarray.Dataset is returned. The data is sorted along the ‘module’ dimension. The array dimension have the order ‘trainId’, ‘pulse’, ‘module’, ‘x’, ‘y’. This order is required by the extra\_geometry package.

**Parameters**

- **filenames** (*list of str*) – files to be combined as a list of names. Calls ‘\_data\_from\_list’ to actually load the data.
- **data\_list** (*list*) – list containing the already loaded data

**Returns**

**data** – A xarray.Dataset containing the combined data.

**Return type**

xarray.Dataset

`toolbox_scs.detectors.load_xarray(fname, group='data', form='dataset')`

Load stored xarray Dataset. Comment: This function exists because of a problem with the standard netcdf engine that is malfunctioning due to related software installed in the exfel-python environment. May be dropped at some point.

#### Parameters

- **fname** (*str*) – filename as string
- **group** (*str*) – the name of the xarray dataset (group in h5 file).
- **form** (*str*) – specify whether the data to be loaded is a ‘dataset’ or a ‘array’.

`toolbox_scs.detectors.save_attributes_h5(fname, data={})`

Adding attributes to a hdf5 file. This function is intended to be used to attach metadata to a processed run.

#### Parameters

- **fname** (*str*) – filename as string
- **data** (*dictionary*) – the data that should be added to the file in form of a dictionary.

`toolbox_scs.detectors.save_xarray(fname, data, group='data', mode='a')`

Store xarray Dataset in the specified location

#### Parameters

- **data** (*xarray.DataSet*) – The data to be stored
- **fname** (*str, int*) – filename
- **overwrite** (*bool*) – overwrite existing data

#### Raises

**`ToolBoxFileError`** – Exception: File existed, but overwrite was set to False.

`toolbox_scs.detectors.create_dssc_bins(name, coordinates, bins)`

Creates a single entry for the dssc binner dictionary. The produced xarray data-array will later be used to perform grouping operations according to the given bins.

#### Parameters

- **name** (*str*) – name of the coordinate to be binned.
- **coordinates** (*numpy.ndarray*) – the original coordinate values (1D)
- **bins** (*numpy.ndarray*) – the bins according to which the corresponding dimension should be grouped.

#### Returns

**da** – A pre-formatted `xarray.DataArray` relating the specified dimension with its bins.

#### Return type

`xarray.DataArray`

## Examples

```
>>> import toolbox_scs as tb
>>> run = tb.open_run(2212, 235, include='*DA*')
```

1.) binner along ‘pulse’ dimension. Group data into two bins. >>> bins\_pulse = ['pumped', 'unpumped'] \* 10  
>>> binner\_pulse = tb.create\_dssc\_bins("pulse",  
np.linspace(0,19,20, dtype=int), bins\_pulse)

2.) **binner along ‘train’ dimension. Group data into bins corresponding to the positions of a delay stage for instance.**

```
>>> bins_trainId = tb.get_array(run, 'PP800_PhaseShifter', 0.04)
>>> binner_train = tb.create_dssc_bins("trainId",
run.trainIds,
bins_trainId.values)
```

`toolbox_scs.detectors.get_xgm_formatted(run_obj, xgm_name, dssc_frame_coords)`

Load the xgm data and define coordinates along the pulse dimension.

### Parameters

- **run\_obj** (*extra\_data.DataCollection*) – DataCollection object providing access to the xgm data to be loaded
- **xgm\_name** (*str*) – valid mnemonic of a xgm source
- **dssc\_frame\_coords** (*int, list*) – defines which dssc frames should be normalized using data from the xgm.

### Returns

**xgm** – xgm data with coordinate ‘pulse’.

### Return type

`xarray.DataArray`

`toolbox_scs.detectors.load_dssc_info(proposal, run_nr)`

Loads the first data file for DSSC module 0 (this is hardcoded) and returns the detector\_info dictionary

### Parameters

- **proposal** (*str, int*) – number of proposal
- **run\_nr** (*str, int*) – number of run

### Returns

**info** – {‘dims’: tuple, ‘frames\_per\_train’: int, ‘total\_frames’: int}

### Return type

dictionary

`toolbox_scs.detectors.load_mask(fname, dssc_mask)`

Load a DSSC mask file.

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### Parameters

**fname** (*str*) – string of the filename of the mask file

**Return type**

dssc\_mask

`toolbox_scs.detectors.quickmask_DSSC_ASIC(poslist)`

Returns a mask for the given DSSC geometry with ASICs given in `poslist` blanked. `poslist` is a list of (module, row, column) tuples. Each module consists of 2 rows and 8 columns of individual ASICs.

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`toolbox_scs.detectors.process_dssc_data(proposal, run_nr, module, chunksize, info, dssc_binnners, path='./', pulsemask=None, dark_image=None, xgm_mnemonic='SCS_SA3', xgm_normalization=False, normevery=1)`

Collects and reduces DSSC data for a single module.

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**Parameters**

- **proposal** (*int*) – proposal number
- **run\_nr** (*int*) – run number
- **module** (*int*) – DSSC module to process
- **chunksize** (*int*) – number of trains to load simultaneously
- **info** (*dictionary*) – dictionary containing keys ‘dims’, ‘frames\_per\_train’, ‘total\_frames’, ‘trainIds’, ‘number\_of\_trains’.
- **dssc\_binnners** (*dictionary*) – a dictionary containing binner objects created by the Tool-Box member function “create\_binner()”
- **path** (*str*) – location in which the .h5 files, containing the binned data, should be stored.
- **pulsemask** (*numpy.ndarray*) – array of booleans to be used to mask dssc data according to xgm data.
- **dark\_image** (*xarray.DataArray*) – an xarray dataarray with matching coordinates with the loaded data. If `dark_image` is not `None` it will be subtracted from each individual dssc frame.
- **xgm\_normalization** (*bool*) – true if the data should be divided by the corresponding xgm value.
- **xgm\_mnemonic** (*str*) – Mnemonic of the xgm data to be used for normalization.
- **normevery** (*int*) – One out of `normevery` dssc frames will be normalized.

**Returns**

**module\_data** – xarray datastructure containing data binned according to bins.

**Return type**

xarray.Dataset

`toolbox_scs.detectors.extract_GH2(ds, run, firstFrame=0, bunchPattern='scs_ppl', gh2_dim='gh2_pId')`

Select and align the frames of the Gotthard-II that have been exposed to light.

**Parameters**

- **ds** (*xarray.Dataset*) – The dataset containing GH2 data
- **run** (*extra\_data.DataCollection*) – The run containing the bunch pattern source

- **firstFrame** (*int*) – The GH2 frame number corresponding to the first pulse of the train.
- **bunchPattern** (*str in ['scs\_pp1', 'sase3']*) – the bunch pattern used to align data. For 'scs\_pp1', the gh2\_pId dimension is renamed 'ol\_pId', and for 'sase3' gh2\_pId is renamed 'sa3\_pId'.
- **gh2\_dim** (*str*) – The name of the dimension that corresponds to the Gotthard-II frames.

**Returns**

**nds** – The aligned and reduced dataset with only-data-containing GH2 variables.

**Return type**

xarray Dataset

**class** toolbox\_scs.detectors.**hRIXS**(*proposalNB, detector='MaranaX'*)

The hRIXS analysis, especially curvature correction

The objects of this class contain the meta-information about the settings of the spectrometer, not the actual data, except possibly a dark image for background subtraction.

The actual data is loaded into `xarray`s, and stays there.

**PROPOSAL**

the number of the proposal

**Type**

int

**DETECTOR**

the detector to be used. Can be ['hRIXS\_det', 'MaranaX'] defaults to 'hRIXS\_det' for backward-compatibility.

**Type**

str

**X\_RANGE**

the slice to take in the dispersive direction, in pixels. Defaults to the entire width.

**Type**

slice

**Y\_RANGE**

the slice to take in the energy direction

**Type**

slice

**THRESHOLD**

pixel counts above which a hit candidate is assumed, for centroiding. use None if you want to give it in standard deviations instead.

**Type**

float

**STD\_THRESHOLD**

same as THRESHOLD, in standard deviations.

**DBL\_THRESHOLD**

threshold controlling whether a detected hit is considered to be a double hit.



**BINS**

the number of bins used in centroiding

**Type**

int

**CURVE\_A, CURVE\_B**

the coefficients of the parabola for the curvature correction

**Type**

float

**USE\_DARK**

whether to do dark subtraction. Is initially *False*, magically switches to *True* if a dark has been loaded, but may be reset.

**Type**

bool

**ENERGY\_INTERCEPT, ENERGY\_SLOPE**

The calibration from pixel to energy

**FIELDS**

the fields to be loaded from the data. Add additional fields if so desired.

**Example**

```
proposal = 3145 h = hRIXS(proposal) h.Y_RANGE = slice(700, 900) h.CURVE_B = -3.695346575286939e-07
h.CURVE_A = 0.024084479232443695 h.ENERGY_SLOPE = 0.018387 h.ENERGY_INTERCEPT = 498.27
h.STD_THRESHOLD = 3.5
```

**DETECTOR\_FIELDS****aggregators**

```
set_params(**params)
```

```
get_params(*params)
```

```
from_run(runNB, proposal=None, extra_fields=(), drop_first=False, subset=None)
```

load a run

Load the run *runNB*. A thin wrapper around *toolbox.load*. :param drop\_first: if True, the first image in the run is removed from the dataset. :type drop\_first: bool

**Example**

```
data = h.from_run(145) # load run 145
```

```
data1 = h.from_run(145) # load run 145 data2 = h.from_run(155) # load run 155 data = xarray.concat([data1, data2], 'trainId') # combine both
```

```
load_dark(runNB, proposal=None)
```

load a dark run

Load the dark run *runNB* from *proposal*. The latter defaults to the current proposal. The dark is stored in this *hRIXS* object, and subsequent analyses use it for background subtraction.

### Example

```
h.load_dark(166) # load dark run 166
```

```
find_curvature(runNB, proposal=None, plot=True, args=None, **kwargs)
```

find the curvature correction coefficients

The hRIXS has some aberrations which leads to the spectroscopic lines being curved on the detector. We approximate these aberrations with a parabola for later correction.

Load a run and determine the curvature. The curvature is set in *self*, and returned as a pair of floats.

#### Parameters

- **runNB** (*int*) – the run number to use
- **proposal** (*int*) – the proposal to use, default to the current proposal
- **plot** (*bool*) – whether to plot the found curvature onto the data
- **args** (*pair of float, optional*) – a starting value to prime the fitting routine

### Example

```
h.find_curvature(155) # use run 155 to fit the curvature
```

```
centroid_one(image)
```

find the position of photons with sub-pixel precision

A photon is supposed to have hit the detector if the intensity within a 2-by-2 square exceeds a threshold. In this case the position of the photon is calculated as the center-of-mass in a 4-by-4 square.

Return the list of x, y coordinate pairs, corrected by the curvature.

```
centroid_two(image, energy)
```

determine position of photon hits on detector

The algorithm is taken from the ESRF RIXS toolbox. The thresholds for determining photon hits are given by the incident photon energy

The function returns arrays containing the single and double hits as x and y coordinates

```
centroid(data, bins=None, method='auto')
```

calculate a spectrum by finding the centroid of individual photons

This takes the *xarray.Dataset* *data* and returns a copy of it, with a new *xarray.DataArray* named *spectrum* added, which contains the energy spectrum calculated for each hRIXS image.

Added a key for switching between algorithms choices are “auto” and “manual” which selects for method for determining whether thresholds there is a photon hit. It changes whether *centroid\_one* or *centroid\_two* is used.

### Example

```
h.centroid(data) # find photons in all images of the run data.spectrum[0, :].plot() # plot the spectrum of the first image
```

#### **parabola**(*x*)

#### **integrate**(*data*)

calculate a spectrum by integration

This takes the *xarray data* and returns a copy of it, with a new dataarray named *spectrum* added, which contains the energy spectrum calculated for each hRIXS image.

First the energy that corresponds to each pixel is calculated. Then all pixels within an energy range are summed, where the intensity of one pixel is distributed among the two energy ranges the pixel spans, proportionally to the overlap between the pixel and bin energy ranges.

The resulting data is normalized to one pixel, so the average intensity that arrived on one pixel.

### Example

```
h.integrate(data) # create spectrum by summing pixels data.spectrum[0, :].plot() # plot the spectrum of the first image
```

#### **aggregator**(*da, dim*)

#### **aggregate**(*ds, var=None, dim='trainId'*)

aggregate (i.e. mostly sum) all data within one dataset

take all images in a dataset and aggregate them and their metadata. For images, spectra and normalizations that means adding them, for others (e.g. delays) adding would not make sense, so we treat them properly. The aggregation functions of each variable are defined in the aggregators attribute of the class. If *var* is specified, group the dataset by *var* prior to aggregation. A new variable “counts” gives the number of frames aggregated in each group.

#### Parameters

- **ds** (*xarray Dataset*) – the dataset containing RIXS data
- **var** (*string*) – One of the variables in the dataset. If *var* is specified, the dataset is grouped by *var* prior to aggregation. This is useful for sorting e.g. a dataset that contains multiple delays.
- **dim** (*string*) – the dimension over which to aggregate the data

### Example

```
h.centroid(data) # create spectra from finding photons
agg = h.aggregate(data) # sum all spectra
agg.spectrum.plot() # plot the resulting spectrum
```

```
agg2 = h.aggregate(data, 'hRIXS_delay') # group data by delay
agg2.spectrum[0, :].plot() # plot the spectrum for first value
```

#### **aggregate\_ds**(*ds, dim='trainId'*)

#### **normalize**(*data, which='hRIXS\_norm'*)

Adds a ‘normalized’ variable to the dataset defined as the ration between ‘spectrum’ and ‘which’

#### Parameters

- **data** (*xarray Dataset*) – the dataset containing hRIXS data
- **which** (*string*, *default="hRIXS\_norm"*) – one of the variables of the dataset, usually “hRIXS\_norm” or “counts”

**class** `toolbox_scs.detectors.MaranaX(*args, **kwargs)`

Bases: *hRIXS*

A spin-off of the hRIXS class: with parallelized centroiding

**NUM\_MAX\_HITS** = 30

**centroid**(*data*, *bins=None*, *\*\*kwargs*)

calculate a spectrum by finding the centroid of individual photons

This takes the *xarray.Dataset data* and returns a copy of it, with a new *xarray.DataArray* named *spectrum* added, which contains the energy spectrum calculated for each hRIXS image.

Added a key for switching between algorithms choices are “auto” and “manual” which selects for method for determining whether thresholds there is a photon hit. It changes whether *centroid\_one* or *centroid\_two* is used.

### Example

```
h.centroid(data) # find photons in all images of the run
data.spectrum[0, :].plot() # plot the spectrum of the first image
```

**\_centroid\_tb\_map**(*\_, index, data*)

**\_centroid\_map**(*index, \*, image, energy*)

**\_centroid\_task**(*index, image, energy*)

**\_histogram\_task**(*index, total, double, default\_range*)

**centroid\_from\_run**(*runNB, proposal=None, extra\_fields=(), drop\_first=False, subset=None, bins=None, return\_hits=False*)

A combined function of *from\_run()* and *centroid()*, which uses *extra\_data* and *pasha* to avoid bulk loading of files.

**\_centroid\_ed\_map**(*\_, index, trainId, data*)

**static \_mnemo\_to\_prop**(*mnemo*)

**\_is\_mnemo\_in\_run**(*mnemo, run*)

`toolbox_scs.detectors.get_pes_params(run, channel=None)`

Extract PES parameters for a given *extra\_data DataCollection*. Parameters are gas, binding energy, retardation voltages or all voltages of the MPOD.

#### Parameters

- **run** (*extra\_data.DataCollection*) – *DataCollection* containing the digitizer data
- **channel** (*str*) – Channel name or PES mnemonic, e.g. ‘2A’ or ‘PES\_1Craw’. If *None*, or if the channel is not found in the data, the retardation voltage for all channels is retrieved.

#### Returns

**params** – dictionary of PES parameters

**Return type**

dict

```
toolbox_scs.detectors.get_pes_tof(proposal, runNB, mnemonic, start=0, origin=None, width=None,
                                  subtract_baseline=False, baseStart=None, baseWidth=40,
                                  merge_with=None)
```

Extracts time-of-flight spectra from raw digitizer traces. The spectra are aligned by pulse Id using the SASE 3 bunch pattern. If origin is not None, a time coordinate in nanoseconds 'time\_ns' is computed and added to the DataArray.

**Parameters**

- **proposal** (*int*) – The proposal number.
- **runNB** (*int*) – The run number.
- **mnemonic** (*str*) – mnemonic for PES, e.g. "PES\_2Araw".
- **start** (*int*) – starting sample of the first spectrum in the raw trace.
- **origin** (*int*) – sample of the trace that corresponds to time-of-flight origin, also called prompt. Used to compute the 'time\_ns' coordinates. If None, computation of 'time\_ns' is skipped.
- **width** (*int*) – number of samples per spectra. If None, the number of samples for 4.5 MHz repetition rate is used.
- **subtract\_baseline** (*bool*) – If True, subtract baseline defined by baseStart and baseWidth to each spectrum.
- **baseStart** (*int*) – starting sample of the baseline.
- **baseWidth** (*int*) – number of samples to average (starting from baseStart) for baseline calculation.
- **merge\_with** (*xarray Dataset*) – If provided, the resulting Dataset will be merged with this one.

**Returns**

**pes** – DataArray containing the PES time-of-flight spectra.

**Return type**

xarray DataArray

**Example**

```
>>> import toolbox_scs as tb
>>> import toolbox_scs.detectors as tbdet
>>> proposal, runNB = 900447, 12
>>> pes = tbdet.get_pes_tof(proposal, runNB, 'PES_2Araw',
>>>                          start=2557, origin=76)
```

```
toolbox_scs.detectors.save_pes_avg_traces(proposal, runNB, channels=None,
                                          subdir='usr/processed_runs')
```

Save average traces of PES into an h5 file.

**Parameters**

- **proposal** (*int*) – The proposal number.
- **runNB** (*int*) – The run number.

- **channels** (*str or list*) – The PES channels or mnemonics, e.g. ‘2A’, [‘2A’, ‘3C’], [‘PES\_1Araw’, ‘PES\_4Draw’, ‘3B’]
- **subdir** (*str*) – subdirectory. The data is stored in <proposal path>/<subdir>/r{runNB:04d}/f{r{runNB:04d}-pes-data.h5’
- **Output** –
- -----
- **traces.** (*xarray Dataset saved in a h5 file containing the PES average*)
- 

```
toolbox_scs.detectors.load_pes_avg_traces(proposal, runNB, channels=None,
                                          subdir='usr/processed_runs')
```

Load existing PES average traces.

#### Parameters

- **proposal** (*int*) – The proposal number.
- **runNB** (*int*) – The run number.
- **channels** (*str or list*) – The PES channels or mnemonics, e.g. ‘2A’, [‘2A’, ‘3C’], [‘PES\_1Araw’, ‘PES\_4Draw’, ‘3B’]
- **subdir** (*str*) – subdirectory. The data is stored in <proposal path>/<subdir>/r{runNB:04d}/f{r{runNB:04d}-pes-data.h5’
- **Output** –
- -----
- **ds** (*xarray Dataset*) – dataset containing the PES average traces.

```
class toolbox_scs.detectors.Viking(proposalNB)
```

The Viking analysis (spectrometer used in combination with Andor Newton camera)

The objects of this class contain the meta-information about the settings of the spectrometer, not the actual data, except possibly a dark image for background subtraction.

The actual data is loaded into *xarray*’s via the method *from\_run()*, and stays there.

#### PROPOSAL

the number of the proposal

##### Type

int

#### X\_RANGE

the slice to take in the non-dispersive direction, in pixels. Defaults to the entire width.

##### Type

slice

#### Y\_RANGE

the slice to take in the energy dispersive direction

##### Type

slice

#### USE\_DARK

whether to do dark subtraction. Is initially *False*, magically switches to *True* if a dark has been loaded, but may be reset.

**Type**  
bool

**ENERGY\_CALIB**

The 2nd degree polynomial coefficients for calibration from pixel to energy. Defaults to [0, 1, 0] (no calibration applied).

**Type**  
1D array (len=3)

**BL\_POLY\_DEG**

the degree of the polynomial used for baseline subtraction. Defaults to 1.

**Type**  
int

**BL\_SIGNAL\_RANGE**

the dispersive-axis range, defined by an interval [min, max], to avoid when fitting a polynomial for baseline subtraction. Multiple ranges can be provided in the form [[min1, max1], [min2, max2], ...].

**Type**  
list

**FIELDS**

the fields to be loaded from the data. Add additional fields if so desired.

**Type**  
list of str

**Example**

```
proposal = 2953 v = Viking(proposal) v.X_RANGE = slice(0, 1900) v.Y_RANGE = slice(38, 80)
v.ENERGY_CALIB = [1.47802667e-06, 2.30600328e-02, 5.15884589e+02] v.BL_SIGNAL_RANGE = [500, 545]
```

```
set_params(**params)
```

```
get_params(*params)
```

```
from_run(runNB, add_attrs=True)
```

load a run

Load the run *runNB*. A thin wrapper around *toolbox\_scs.load*.

**Parameters**

- **runNB** (*int*) – the run number
- **add\_attrs** (*bool*) – if True, adds the camera parameters as attributes to the dataset (see `get_camera_params()`)
- **Output** –
- -----
- **ds** (*xarray Dataset*) – the dataset containing the camera images

### Example

```
data = v.from_run(145) # load run 145
```

```
data1 = v.from_run(145) # load run 145 data2 = v.from_run(155) # load run 155 data = xarray.concat([data1, data2], 'trainId') # combine both
```

```
load_dark(runNB=None)
```

```
integrate(data)
```

This function calculates the mean over the non-dispersive dimension to create a spectrum. If the camera parameters are known, the spectrum is multiplied by the number of photoelectrons per ADC count. A new variable “spectrum” is added to the data.

```
get_camera_gain(run)
```

Get the preamp gain of the camera in the Viking spectrometer for a specified run.

#### Parameters

- **run** (*extra\_data DataCollection*) – information on the run
- **Output** –
- -----
- **gain** (*int*) –

```
e_per_counts(run, gain=None)
```

Conversion factor from camera digital counts to photoelectrons per count. The values can be found in the camera datasheet (Andor Newton) but they have been slightly corrected for High Sensitivity mode after analysis of runs 1204, 1207 and 1208, proposal 2937.

#### Parameters

- **run** (*extra\_data DataCollection*) – information on the run
- **gain** (*int*) – the camera preamp gain
- **Output** –
- -----
- **ret** (*float*) – photoelectrons per count

```
get_camera_params(run)
```

```
removePolyBaseline(data)
```

Removes a polynomial baseline to a spectrum, assuming a fixed position for the signal.

#### Parameters

- **data** (*xarray Dataset*) – The Viking data containing the variable “spectrum”
- **Output** –
- -----
- **data** – the original dataset with the added variable “spectrum\_nobl” containing the baseline subtracted spectra.

```
xas(data, data_ref, thickness=1, plot=False, plot_errors=True, xas_ylim=(-1, 3))
```

Given two independent datasets (one with sample and one reference), this calculates the average XAS spectrum (absorption coefficient), associated standard deviation and standard error. The absorption coefficient is defined as  $-\log(I_t/I_0)/\text{thickness}$ .



**Parameters**

- **data** (*xarray Dataset*) – the dataset containing the spectra with sample
- **data\_ref** (*xarray Dataset*) – the dataset containing the spectra without sample
- **thickness** (*float*) – the thickness used for the calculation of the absorption coefficient
- **plot** (*bool*) – If True, plot the resulting average spectra.
- **plot\_errors** (*bool*) – If True, adds the 95% confidence interval on the spectra.
- **xas\_ylim** (*tuple or list of float*) – the y limits for the XAS plot.
- **Output** –
- -----
- **xas** (*xarray Dataset*) – the dataset containing the computed XAS quantities: IO, It, absorptionCoef and their associated errors.

**calibrate**(*runList, plot=True*)

This routine determines the calibration coefficients to translate the camera pixels into energy in eV. The Viking spectrometer is calibrated using the beamline monochromator: runs with various monochromatized photon energy are recorded and their peak position on the detector are determined by Gaussian fitting. The energy vs. position data is then fitted to a second degree polynomial.

**Parameters**

- **runList** (*list of int*) – the list of runs containing the monochromatized spectra
- **plot** (*bool*) – if True, the spectra, their Gaussian fits and the calibration curve are plotted.
- **Output** –
- -----
- **energy\_calib** (*np. array*) – the calibration coefficients (2nd degree polynomial)

**toolbox\_scs.detectors.calibrate\_xgm**(*run, data, xgm='SCS', plot=False*)

Calculates the calibration factor F between the photon flux (slow signal) and the fast signal (pulse-resolved) of the sase 3 pulses. The calibrated fast signal is equal to the uncalibrated one multiplied by F.

**Parameters**

- **run** (*extra\_data.DataCollection*) – DataCollection containing the digitizer data.
- **data** (*xarray Dataset*) – dataset containing the pulse-resolved sase 3 signal, e.g. 'SCS\_SA3'
- **xgm** (*str*) – one in {'XTD10', 'SCS'}
- **plot** (*bool*) – If True, shows a plot of the photon flux, averaged fast signal and calibrated fast signal.

**Returns**

**F** – calibration factor F defined as: calibrated XGM [microJ] = F \* fast XGM array ('SCS\_SA3' or 'XTD10\_SA3')

**Return type**

float

### Example

```
>>> import toolbox_scs as tb
>>> import toolbox_scs.detectors as tbdet
>>> run, data = tb.load(900074, 69, ['SCS_XGM'])
>>> ds = tbdet.get_xgm(run, merge_with=data)
>>> F = tbdet.calibrate_xgm(run, ds, plot=True)
>>> # Add calibrated XGM to the dataset:
>>> ds['SCS_SA3_uJ'] = F * ds['SCS_SA3']
```

`toolbox_scs.detectors.get_xgm(run, mnemonics=None, merge_with=None, indices=slice(0, None))`

Load and/or computes XGM data. Sources can be loaded on the fly via the `mnemonics` argument, or processed from an existing dataset (`merge_with`). The bunch pattern table is used to assign the pulse id coordinates if the number of pulses has changed during the run.

#### Parameters

- **run** (*extra\_data.DataCollection*) – DataCollection containing the xgm data.
- **mnemonics** (*str or list of str*) – mnemonics for XGM, e.g. “SCS\_SA3” or [“XTD10\_XGM”, “SCS\_XGM”]. If None, defaults to “SCS\_SA3” in case no `merge_with` dataset is provided.
- **merge\_with** (*xarray Dataset*) – If provided, the resulting Dataset will be merged with this one. The XGM variables of `merge_with` (if any) will also be computed and merged.
- **indices** (*slice, list, 1D array*) – Pulse indices of the XGM array in case bunch pattern is missing.

#### Returns

merged with Dataset `merge_with` if provided.

#### Return type

xarray Dataset with pulse-resolved XGM variables aligned,

### Example

```
>>> import toolbox_scs as tb
>>> run, ds = tb.load(2212, 213, 'SCS_SA3')
>>> ds['SCS_SA3']
```

`toolbox_scs.detectors.__all__`

`toolbox_scs.misc`

### Submodules

`toolbox_scs.misc.bunch_pattern`

Toolbox for SCS.

Various utilities function to quickly process data measured at the SCS instruments.

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## Module Contents

### Functions

<code>npulses_has_changed(run[, loc, run_mnemonics])</code>	Checks if the number of pulses has changed during the run for
<code>get_sase_pId(run[, loc, run_mnemonics, bpt, merge_with])</code>	Returns the pulse Ids of the specified <i>loc</i> during a run.
<code>extractBunchPattern([bp_table, key, runDir])</code>	generate the bunch pattern and number of pulses of a source directly from the
<code>pulsePatternInfo(data[, plot])</code>	display general information on the pulse patterns operated by SASE1 and SASE3.
<code>repRate([data, runNB, proposalNB, key])</code>	Calculates the pulse repetition rate (in kHz) in sase

`toolbox_scs.misc.bunch_pattern.npulses_has_changed(run, loc='sase3', run_mnemonics=None)`

Checks if the number of pulses has changed during the run for a specific location *loc* (='sase1', 'sase3', 'scs\_ppl' or 'laser') If the source is not found in the run, returns True.

#### Parameters

- **run** (*extra\_data.DataCollection*) – DataCollection containing the data.
- **loc** (*str*) – The location where to check: {'sase1', 'sase3', 'scs\_ppl' }
- **run\_mnemonics** (*dict*) – the mnemonics for the run (see *menonics\_for\_run*)

#### Returns

**ret** – True if the number of pulses has changed or the source was not found, False if the number of pulses did not change.

#### Return type

bool

`toolbox_scs.misc.bunch_pattern.get_sase_pId(run, loc='sase3', run_mnemonics=None, bpt=None, merge_with=None)`

Returns the pulse Ids of the specified *loc* during a run. If the number of pulses has changed during the run, it loads the bunch pattern table and extract all pulse Ids used.

#### Parameters

- **run** (*extra\_data.DataCollection*) – DataCollection containing the data.
- **loc** (*str*) – The location where to check: {'sase1', 'sase3', 'scs\_ppl' }
- **run\_mnemonics** (*dict*) – the mnemonics for the run (see *menonics\_for\_run*)
- **bpt** (*2D-array*) – The bunch pattern table. Used only if the number of pulses has changed. If None, it is loaded on the fly.
- **merge\_with** (*xarray.Dataset*) – dataset that may contain the bunch pattern table to use in case the number of pulses has changed. If *merge\_with* does not contain the bunch pattern table, it is loaded and added as a variable 'bunchPatternTable' to *merge\_with*.

#### Returns

**pulseIds** – the pulse ids at the specified location. Returns None if the mnemonic is not in the run.

#### Return type

np.array

`toolbox_scs.misc.bunch_pattern.extractBunchPattern(bp_table=None, key='sase3', runDir=None)`

generate the bunch pattern and number of pulses of a source directly from the bunch pattern table and not using the MDL device BUNCH\_DECODER. This is inspired by the `euxfel_bunch_pattern` package, [https://git.xfel.eu/gitlab/karaboDevices/euxfel\\_bunch\\_pattern](https://git.xfel.eu/gitlab/karaboDevices/euxfel_bunch_pattern) Inputs:

**bp\_table:** **DataArray** corresponding to the mnemonics “**bunchPatternTable**”.

If `None`, the bunch pattern table is loaded using `runDir`.

`key:` str, [`'sase1'`, `'sase2'`, `'sase3'`, `'scs_ppl'`] `runDir:` extra-data `DataCollection`. Required only if `bp_table` is `None`.

**Outputs:**

`bunchPattern:` `DataArray` containing indices of the sase/laser pulses for each train `npulses:` `DataArray` containing the number of pulses for each train matched: 2-D `DataArray` mask (trainId x 2700), True where ‘key’ has pulses

`toolbox_scs.misc.bunch_pattern.pulsePatternInfo(data, plot=False)`

display general information on the pulse patterns operated by SASE1 and SASE3. This is useful to track changes of number of pulses or mode of operation of SASE1 and SASE3. It also determines which SASE comes first in the train and the minimum separation between the two SASE sub-trains.

**Inputs:**

`data:` xarray `Dataset` containing pulse pattern info from the bunch decoder MDL: {`'sase1'`, `'sase3'`, `'npulses_sase1'`, `'npulses_sase3'`} `plot:` bool enabling/disabling the plotting of the pulse patterns

**Outputs:**

print of pulse pattern info. If `plot==True`, plot of the pulse pattern.

`toolbox_scs.misc.bunch_pattern.repRate(data=None, runNB=None, proposalNB=None, key='sase3')`

Calculates the pulse repetition rate (in kHz) in sase according to the bunch pattern and assuming a grid of 4.5 MHz.

**Inputs:**

`data:` xarray `Dataset` containing pulse pattern, needed if `runNB` is none `runNB:` int or str, run number. Needed if `data` is `None` `proposal:` int or str, proposal where to find the run. Needed if `data` is `None` `key:` str in [`'sase1'`, `'sase2'`, `'sase3'`, `'scs_ppl'`], source for which the

repetition rate is calculated

**Output:**

f: repetition rate in kHz

## toolbox\_scs.misc.bunch\_pattern\_external

A collection of wrappers around the the `euxfel_bunch_pattern` pkg

The `euxfel_bunch_pattern` package provides generic methods to extract information from the bunch pattern tables. To ease its use from within the toolbox some of its methods are wrapped. Like this they show up in the users namespace in a self-explanatory way.

### Module Contents

#### Functions

<code>is_pulse_at(bpt, loc)</code>	Check for presence of a pulse at the location provided.
<code>is_sase_3(bpt)</code>	Check for presence of a SASE3 pulse.
<code>is_sase_1(bpt)</code>	Check for presence of a SASE1 pulse.
<code>is_ppl(bpt)</code>	Check for presence of pp-laser pulse.

`toolbox_scs.misc.bunch_pattern_external.is_pulse_at(bpt, loc)`

Check for presence of a pulse at the location provided.

#### Parameters

- **bpt** (*numpy array, xarray DataArray*) – The bunch pattern data.
- **loc** (*str*) – The location where to check: { 'sase1', 'sase3', 'scs\_ppl' }

#### Returns

**boolean** – true if a pulse is present at *loc*.

#### Return type

*numpy array, xarray DataArray*

`toolbox_scs.misc.bunch_pattern_external.is_sase_3(bpt)`

Check for presence of a SASE3 pulse.

#### Parameters

**bpt** (*numpy array, xarray DataArray*) – The bunch pattern data.

#### Returns

**boolean** – true if SASE3 pulse is present.

#### Return type

*numpy array, xarray DataArray*

`toolbox_scs.misc.bunch_pattern_external.is_sase_1(bpt)`

Check for presence of a SASE1 pulse.

#### Parameters

**bpt** (*numpy array, xarray DataArray*) – The bunch pattern data.

#### Returns

**boolean** – true if SASE1 pulse is present.

#### Return type

*numpy array, xarray DataArray*

`toolbox_scs.misc.bunch_pattern_external.is_pp1` (*bpt*)

Check for presence of pp-laser pulse.

**Parameters**

**bpt** (*numpy array, xarray DataArray*) – The bunch pattern data.

**Returns**

**boolean** – true if pp-laser pulse is present.

**Return type**

numpy array, xarray DataArray

`toolbox_scs.misc.laser_utils`

## Module Contents

### Functions

---

<code>positionToDelay</code> ( <i>pos</i> [, <i>origin</i> , <i>invert</i> , <i>reflections</i> ])	converts a motor position in mm into optical delay in picosecond
<code>delayToPosition</code> ( <i>delay</i> [, <i>origin</i> , <i>invert</i> , <i>reflections</i> ])	converts an optical delay in picosecond into a motor position in mm
<code>degToRelPower</code> ( <i>x</i> [, <i>theta0</i> ])	converts a half-wave plate position in degrees into relative power
<code>fluenceCalibration</code> ( <i>hwp</i> , <i>power_mW</i> , <i>npulses</i> , <i>w0x</i> [, <i>w0y</i> , ...])	Given a measurement of relative powers or half wave plate angles
<code>align_ol_to_fel_pId</code> ( <i>ds</i> [, <i>ol_dim</i> , <i>fel_dim</i> , <i>offset</i> , ...])	Aligns the optical laser (OL) pulse Ids to the FEL pulse Ids.

---

`toolbox_scs.misc.laser_utils.positionToDelay` (*pos*, *origin=0*, *invert=True*, *reflections=1*)

converts a motor position in mm into optical delay in picosecond Inputs:

*pos*: array-like delay stage motor position *origin*: motor position of time zero in mm *invert*: bool, inverts the sign of delay if True *reflections*: number of bounces in the delay stage

**Output:**

delay in picosecond

`toolbox_scs.misc.laser_utils.delayToPosition` (*delay*, *origin=0*, *invert=True*, *reflections=1*)

converts an optical delay in picosecond into a motor position in mm Inputs:

*delay*: array-like delay in ps *origin*: motor position of time zero in mm *invert*: bool, inverts the sign of delay if True *reflections*: number of bounces in the delay stage

**Output:**

delay in picosecond

`toolbox_scs.misc.laser_utils.degToRelPower` (*x*, *theta0=0*)

converts a half-wave plate position in degrees into relative power between 0 and 1. Inputs:

*x*: array-like positions of half-wave plate, in degrees *theta0*: position for which relative power is zero

**Output:**

array-like relative power

```
toolbox_scs.misc.laser_utils.fluenceCalibration(hwp, power_mW, npulses, w0x, w0y=None,
                                                train_rep_rate=10, fit_order=1, plot=True,
                                                xlabel='HWP [%]')
```

Given a measurement of relative powers or half wave plate angles and averaged powers in mW, this routine calculates the corresponding fluence and fits a polynomial to the data.

**Parameters**

- **hwp** (*array-like* ( $N$ )) – angle or relative power from the half wave plate
- **power\_mW** (*array-like* ( $N$ )) – measured power in mW by powermeter
- **npulses** (*int*) – number of pulses per train during power measurement
- **w0x** (*float*) – radius at  $1/e^2$  in x-axis in meter
- **w0y** (*float, optional*) – radius at  $1/e^2$  in y-axis in meter. If None,  $w0y=w0x$  is assumed.
- **train\_rep\_rate** (*float*) – repetition rate of the FEL, by default equals to 10 Hz.
- **fit\_order** (*int*) – order of the polynomial fit
- **plot** (*bool*) – Plot the results if True
- **xlabel** (*str*) – xlabel for the plot
- **Output** –
- -----
- **F** (*ndarray* ( $N$ )) – fluence in  $\text{mJ}/\text{cm}^2$
- **fit\_F** (*ndarray*) – coefficients of the fluence polynomial fit
- **E** (*ndarray* ( $N$ )) – pulse energy in microJ
- **fit\_E** (*ndarray*) – coefficients of the fluence polynomial fit

```
toolbox_scs.misc.laser_utils.align_ol_to_fel_pId(ds, ol_dim='ol_pId', fel_dim='sa3_pId', offset=0,
                                                fill_value=np.nan)
```

Aligns the optical laser (OL) pulse Ids to the FEL pulse Ids. The new OL coordinates are calculated as  $ds[ol\_dim] + ds[fel\_dim][0] + offset$ . The *ol\_dim* is then removed, and if the number of OL and FEL pulses are different, the missing values are replaced by *fill\_value* (NaN by default).

**Parameters**

- **ds** (*xarray.Dataset*) – Dataset containing both OL and FEL dimensions
- **ol\_dim** (*str*) – name of the OL dimension
- **fel\_dim** (*str*) – name of the FEL dimension
- **offset** (*int*) – offset added to the OL pulse Ids.
- **fill\_value** (*(scalar or dict-like, optional)*) – Value to use for newly missing values. If a dict-like, maps variable names to fill values. Use a data array's name to refer to its values.
- **Output** –
- -----
- **ds** – The newly aligned dataset

toolbox\_scs.misc.undulator

### Module Contents

### Functions

---

<code>get_undulator_config(run[, park_pos, plot])</code>	Extract the undulator cells configuration from a given run.
--	---

---

toolbox\_scs.misc.undulator.**get\_undulator\_config**(run, park\_pos=62.0, plot=True)

Extract the undulator cells configuration from a given run. The gap size and K factor as well as the magnetic chicane delay and photon energy of colors 1, 2 and 3 are compiled into an xarray Dataset.

Note: This function looks at run control values, it does not reflect any change of values during the run. Do not use to extract configuration when scanning the undulator.

#### Parameters

- **run** (*EXtra-Data DataCollection*) – The run containing the undulator information
- **park\_pos** (*float, optional*) – The parked position of a cell (i.e. when fully opened)
- **plot** (*bool, optional*) – If True, plot the undulator cells configuration

#### Returns

**cells** – The resulting dataset of the undulator configuration

#### Return type

xarray Dataset

### Package Contents



## Functions

<code>extractBunchPattern</code> ([bp_table, key, runDir])	generate the bunch pattern and number of pulses of a source directly from the
<code>get_sase_pId</code> (run[, loc, run_mnemonics, bpt, merge_with])	Returns the pulse Ids of the specified <i>loc</i> during a run.
<code>npulses_has_changed</code> (run[, loc, run_mnemonics])	Checks if the number of pulses has changed during the run for
<code>pulsePatternInfo</code> (data[, plot])	display general information on the pulse patterns operated by SASE1 and SASE3.
<code>repRate</code> ([data, runNB, proposalNB, key])	Calculates the pulse repetition rate (in kHz) in sase
<code>is_sase_3</code> (bpt)	Check for prescence of a SASE3 pulse.
<code>is_sase_1</code> (bpt)	Check for prescence of a SASE1 pulse.
<code>is_ppl</code> (bpt)	Check for prescence of pp-laser pulse.
<code>is_pulse_at</code> (bpt, loc)	Check for prescence of a pulse at the location provided.
<code>degToRelPower</code> (x[, theta0])	converts a half-wave plate position in degrees into relative power
<code>positionToDelay</code> (pos[, origin, invert, reflections])	converts a motor position in mm into optical delay in picosecond
<code>delayToPosition</code> (delay[, origin, invert, reflections])	converts an optical delay in picosecond into a motor position in mm
<code>fluenceCalibration</code> (hwp, power_mW, npulses, w0x[, w0y, ...])	Given a measurement of relative powers or half wave plate angles
<code>align_ol_to_fel_pId</code> (ds[, ol_dim, fel_dim, offset, ...])	Aligns the optical laser (OL) pulse Ids to the FEL pulse Ids.
<code>get_undulator_config</code> (run[, park_pos, plot])	Extract the undulator cells configuration from a given run.

## Attributes

`__all__`

`toolbox_scs.misc.extractBunchPattern`(bp\_table=None, key='sase3', runDir=None)

generate the bunch pattern and number of pulses of a source directly from the bunch pattern table and not using the MDL device BUNCH\_DECODER. This is inspired by the `euxfel_bunch_pattern` package, [https://git.xfel.eu/gitlab/karaboDevices/euxfel\\_bunch\\_pattern](https://git.xfel.eu/gitlab/karaboDevices/euxfel_bunch_pattern) Inputs:

**bp\_table:** DataArray corresponding to the mnemonics “bunchPatternTable”.

If None, the bunch pattern table is loaded using runDir.

key: str, ['sase1', 'sase2', 'sase3', 'scs\_ppl'] runDir: extra-data DataCollection. Required only if bp\_table is None.

### Outputs:

bunchPattern: DataArray containing indices of the sase/laser pulses for each train npulses: DataArray containing the number of pulses for each train matched: 2-D DataArray mask (trainId x 2700), True where 'key' has pulses

`toolbox_scs.misc.get_sase_pId(run, loc='sase3', run_mnemonics=None, bpt=None, merge_with=None)`

Returns the pulse Ids of the specified *loc* during a run. If the number of pulses has changed during the run, it loads the bunch pattern table and extract all pulse Ids used.

**Parameters**

- **run** (*extra\_data.DataCollection*) – DataCollection containing the data.
- **loc** (*str*) – The location where to check: {'sase1', 'sase3', 'scs\_ppl' }
- **run\_mnemonics** (*dict*) – the mnemonics for the run (see *menonics\_for\_run*)
- **bpt** (*2D-array*) – The bunch pattern table. Used only if the number of pulses has changed. If None, it is loaded on the fly.
- **merge\_with** (*xarray.Dataset*) – dataset that may contain the bunch pattern table to use in case the number of pulses has changed. If merge\_with does not contain the bunch pattern table, it is loaded and added as a variable 'bunchPatternTable' to merge\_with.

**Returns**

**pulseIds** – the pulse ids at the specified location. Returns None if the mnemonic is not in the run.

**Return type**

np.array

`toolbox_scs.misc.npulses_has_changed(run, loc='sase3', run_mnemonics=None)`

Checks if the number of pulses has changed during the run for a specific location *loc* (='sase1', 'sase3', 'scs\_ppl' or 'laser') If the source is not found in the run, returns True.

**Parameters**

- **run** (*extra\_data.DataCollection*) – DataCollection containing the data.
- **loc** (*str*) – The location where to check: {'sase1', 'sase3', 'scs\_ppl' }
- **run\_mnemonics** (*dict*) – the mnemonics for the run (see *menonics\_for\_run*)

**Returns**

**ret** – True if the number of pulses has changed or the source was not found, False if the number of pulses did not change.

**Return type**

bool

`toolbox_scs.misc.pulsePatternInfo(data, plot=False)`

display general information on the pulse patterns operated by SASE1 and SASE3. This is useful to track changes of number of pulses or mode of operation of SASE1 and SASE3. It also determines which SASE comes first in the train and the minimum separation between the two SASE sub-trains.

**Inputs:**

**data:** xarray Dataset containing pulse pattern info from the bunch decoder MDL: {'sase1, sase3', 'npulses\_sase1', 'npulses\_sase3'} **plot:** bool enabling/disabling the plotting of the pulse patterns

**Outputs:**

print of pulse pattern info. If plot==True, plot of the pulse pattern.

`toolbox_scs.misc.repRate(data=None, runNB=None, proposalNB=None, key='sase3')`

Calculates the pulse repetition rate (in kHz) in sase according to the bunch pattern and assuming a grid of 4.5 MHz.

**Inputs:**

data: xarray Dataset containing pulse pattern, needed if runNB is none  
 runNB: int or str, run number. Needed if data is None  
 proposal: int or str, proposal where to find the run. Needed if data is None  
 key: str in [sase1, sase2, sase3, scs\_ppl], source for which the repetition rate is calculated

**Output:**

f: repetition rate in kHz

`toolbox_scs.misc.is_sase_3(bpt)`

Check for presence of a SASE3 pulse.

**Parameters**

**bpt** (*numpy array, xarray DataArray*) – The bunch pattern data.

**Returns**

**boolean** – true if SASE3 pulse is present.

**Return type**

numpy array, xarray DataArray

`toolbox_scs.misc.is_sase_1(bpt)`

Check for presence of a SASE1 pulse.

**Parameters**

**bpt** (*numpy array, xarray DataArray*) – The bunch pattern data.

**Returns**

**boolean** – true if SASE1 pulse is present.

**Return type**

numpy array, xarray DataArray

`toolbox_scs.misc.is_ppl(bpt)`

Check for presence of pp-laser pulse.

**Parameters**

**bpt** (*numpy array, xarray DataArray*) – The bunch pattern data.

**Returns**

**boolean** – true if pp-laser pulse is present.

**Return type**

numpy array, xarray DataArray

`toolbox_scs.misc.is_pulse_at(bpt, loc)`

Check for presence of a pulse at the location provided.

**Parameters**

- **bpt** (*numpy array, xarray DataArray*) – The bunch pattern data.
- **loc** (*str*) – The location where to check: {'sase1', 'sase3', 'scs\_ppl' }

**Returns**

**boolean** – true if a pulse is present at *loc*.

**Return type**

numpy array, xarray DataArray

`toolbox_scs.misc.degToRelPower(x, theta0=0)`

converts a half-wave plate position in degrees into relative power between 0 and 1. Inputs:

x: array-like positions of half-wave plate, in degrees theta0: position for which relative power is zero

**Output:**

array-like relative power

`toolbox_scs.misc.positionToDelay(pos, origin=0, invert=True, reflections=1)`

converts a motor position in mm into optical delay in picosecond Inputs:

pos: array-like delay stage motor position origin: motor position of time zero in mm invert: bool, inverts the sign of delay if True reflections: number of bounces in the delay stage

**Output:**

delay in picosecond

`toolbox_scs.misc.delayToPosition(delay, origin=0, invert=True, reflections=1)`

converts an optical delay in picosecond into a motor position in mm Inputs:

delay: array-like delay in ps origin: motor position of time zero in mm invert: bool, inverts the sign of delay if True reflections: number of bounces in the delay stage

**Output:**

delay in picosecond

`toolbox_scs.misc.fluenceCalibration(hwp, power_mW, npulses, w0x, w0y=None, train_rep_rate=10, fit_order=1, plot=True, xlabel='HWP [%]')`

Given a measurement of relative powers or half wave plate angles and averaged powers in mW, this routine calculates the corresponding fluence and fits a polynomial to the data.

**Parameters**

- **hwp** (*array-like (N)*) – angle or relative power from the half wave plate
- **power\_mW** (*array-like (N)*) – measured power in mW by powermeter
- **npulses** (*int*) – number of pulses per train during power measurement
- **w0x** (*float*) – radius at  $1/e^2$  in x-axis in meter
- **w0y** (*float, optional*) – radius at  $1/e^2$  in y-axis in meter. If None,  $w0y=w0x$  is assumed.
- **train\_rep\_rate** (*float*) – repetition rate of the FEL, by default equals to 10 Hz.
- **fit\_order** (*int*) – order of the polynomial fit
- **plot** (*bool*) – Plot the results if True
- **xlabel** (*str*) – xlabel for the plot
- **Output** –  
-----
- **F** (*ndarray (N)*) – fluence in  $\text{mJ}/\text{cm}^2$
- **fit\_F** (*ndarray*) – coefficients of the fluence polynomial fit

- **E** (*ndarray (N)*) – pulse energy in microJ
- **fit\_E** (*ndarray*) – coefficients of the fluence polynomial fit

`toolbox_scs.misc.align_ol_to_fel_pId(ds, ol_dim='ol_pId', fel_dim='sa3_pId', offset=0, fill_value=np.nan)`

Aligns the optical laser (OL) pulse Ids to the FEL pulse Ids. The new OL coordinates are calculated as `ds[ol_dim] + ds[fel_dim][0] + offset`. The `ol_dim` is then removed, and if the number of OL and FEL pulses are different, the missing values are replaced by `fill_value` (NaN by default).

#### Parameters

- **ds** (*xarray.Dataset*) – Dataset containing both OL and FEL dimensions
- **ol\_dim** (*str*) – name of the OL dimension
- **fel\_dim** (*str*) – name of the FEL dimension
- **offset** (*int*) – offset added to the OL pulse Ids.
- **fill\_value** (*(scalar or dict-like, optional)*) – Value to use for newly missing values. If a dict-like, maps variable names to fill values. Use a data array's name to refer to its values.
- **Output** –
- ----- –
- **ds** – The newly aligned dataset

`toolbox_scs.misc.get_undulator_config(run, park_pos=62.0, plot=True)`

Extract the undulator cells configuration from a given run. The gap size and K factor as well as the magnetic chicane delay and photon energy of colors 1, 2 and 3 are compiled into an `xarray Dataset`.

Note: This function looks at run control values, it does not reflect any change of values during the run. Do not use to extract configuration when scanning the undulator.

#### Parameters

- **run** (*EXtra-Data DataCollection*) – The run containing the undulator information
- **park\_pos** (*float, optional*) – The parked position of a cell (i.e. when fully opened)
- **plot** (*bool, optional*) – If True, plot the undulator cells configuration

#### Returns

**cells** – The resulting dataset of the undulator configuration

#### Return type

`xarray Dataset`

`toolbox_scs.misc.__all__`

`toolbox_scs.routines`

## Submodules

`toolbox_scs.routines.Reflectivity`

Toolbox for SCS.

Various utilities function to quickly process data measured at the SCS instrument.

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## Module Contents

### Functions

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<i>reflectivity</i> (data[, Iokey, Irkey, delaykey, binWidth, ...])	Computes the reflectivity $R = 100 * (I_r / I_o[\text{pumped}] / I_r / I_o[\text{unpumped}] - 1)$
---	---

---

```
toolbox_scs.routines.Reflectivity.reflectivity(data, Iokey='FastADC5peaks',
                                                Irkey='FastADC3peaks',
                                                delaykey='PP800_DelayLine', binWidth=0.05,
                                                positionToDelay=True, origin=None, invert=False,
                                                pumpedOnly=False, alternateTrains=False,
                                                pumpOnEven=True, lowweights=False, plot=True,
                                                plotErrors=True, units='mm')
```

Computes the reflectivity  $R = 100 * (I_r / I_o[\text{pumped}] / I_r / I_o[\text{unpumped}] - 1)$  as a function of delay. Delay can be a motor position in mm or an optical delay in ps, with possibility to convert from position to delay. The default scheme is alternating pulses pumped/unpumped/... in each train, also possible are alternating trains and pumped only. If fitting is enabled, attempts a double exponential (default) or step function fit.

#### Parameters

- **data** (*xarray Dataset*) – Dataset containing the Io, Ir and delay data
- **Iokey** (*str*) – Name of the Io variable
- **Irkey** (*str*) – Name of the Ir variable
- **delaykey** (*str*) – Name of the delay variable (motor position in mm or optical delay in ps)
- **binWidth** (*float*) – width of bin in units of delay variable
- **positionToDelay** (*bool*) – If True, adds a time axis converted from position axis according to origin and invert parameters. Ignored if origin is None.
- **origin** (*float*) – Position of time overlap, shown as a vertical line. Used if positionToDelay is True to convert position to time axis.
- **invert** (*bool*) – Used if positionToDelay is True to convert position to time axis.
- **pumpedOnly** (*bool*) – Assumes that all trains and pulses are pumped. In this case, Delta R is defined as  $I_r / I_o$ .
- **alternateTrains** (*bool*) – If True, assumes that trains alternate between pumped and unpumped data.
- **pumpOnEven** (*bool*) – Only used if alternateTrains=True. If True, even trains are pumped, if False, odd trains are pumped.
- **lowweights** (*bool*) – If True, computes the ratio of the means instead of the mean of the ratios  $I_r / I_o$ . Useful when dealing with large intensity variations.
- **plot** (*bool*) – If True, plots the results.
- **plotErrors** (*bool*) – If True, plots the 95% confidence interval.
- **Output** –
  - ----- – xarray Dataset containing the binned Delta R, standard deviation, standard error, counts and delays, and the fitting results if full is True.

**toolbox\_scs.routines.XAS**

Toolbox for XAS experiments.

Based on the LCLS LO59 experiment libraries.

Time-resolved XAS and XMCD with uncertainties.

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**Module Contents****Functions**

<code>xas(nrun[, bins, Iokey, Itkey, nrjkey, Iooffset, ...])</code>	Compute the XAS spectra from a xarray nrun.
<code>xasxmcd(dataP, dataN)</code>	Compute XAS and XMCD from data with both magnetic field direction

`toolbox_scs.routines.XAS.xas(nrun, bins=None, Iokey='SCS_SA3', Itkey='MCP3peaks', nrjkey='nrj', Iooffset=0, plot=False, fluorescence=False)`

Compute the XAS spectra from a xarray nrun.

**Inputs:**

nrun: xarray of SCS data bins: an array of bin-edges or an integer number of desired bins or a float for the desired bin width.

Iokey: string for the Io fields, typically 'SCS\_XGM' Itkey: string for the It fields, typically 'MCP3apd' nrjkey: string for the nrj fields, typically 'nrj' Iooffset: offset to apply on Io plot: boolean, displays a XAS spectrum if True fluorescence: boolean, if True, absorption is the ratio,

if False, absorption is negative log

**Outputs:****a dictionary containing:**

nrj: the bin centers muA: the absorption sigmaA: standard deviation on the absorption sterrA: standard error on the absorption muIo: the mean of the Io counts: the number of events in each bin

`toolbox_scs.routines.XAS.xasxmcd(dataP, dataN)`

Compute XAS and XMCD from data with both magnetic field direction Inputs:

dataP: structured array for positive field dataN: structured array for negative field

**Outputs:**

xas: structured array for the sum xmcd: structured array for the difference

### `toolbox_scs.routines.boz`

Beam splitting Off-axis Zone plate analysis routines.

Copyright (2021, 2022, 2023, 2024) SCS Team.

### Module Contents

#### Classes

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<i>parameters</i>	Parameters contains all input parameters for the BOZ corrections.
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## Functions

<i>get_roi_pixel_pos</i> (roi, params)	Compute fake or real pixel position of an roi from roi center.
<i>bad_pixel_map</i> (params)	Compute the bad pixels map.
<i>inspect_dark</i> (arr[, mean_th, std_th])	Inspect dark run data and plot diagnostic.
<i>histogram_module</i> (arr[, mask])	Compute a histogram of the 9 bits raw pixel values over a module.
<i>inspect_histogram</i> (arr[, arr_dark, mask, extra_lines])	Compute and plot a histogram of the 9 bits raw pixel values.
<i>find_rois</i> (data_mean, threshold[, extended])	Find rois from 3 beams configuration.
<i>find_rois_from_params</i> (params)	Find rois from 3 beams configuration.
<i>inspect_rois</i> (data_mean, rois[, threshold, allrois])	Find rois from 3 beams configuration from mean module image.
<i>compute_flat_field_correction</i> (rois, params[, plot])	
<i>inspect_flat_field_domain</i> (avg, rois, prod_th, ratio_th)	Extract beams roi from average image and compute the ratio.
<i>inspect_plane_fitting</i> (avg, rois[, domain, vmin, vmax])	
<i>plane_fitting_domain</i> (avg, rois, prod_th, ratio_th)	Extract beams roi, compute their ratio and the domain.
<i>plane_fitting</i> (params)	Fit the plane flat-field normalization.
<i>ff_refine_crit</i> (p, alpha, params, arr_dark, arr, tid, ...)	Criteria for the ff_refine_fit.
<i>ff_refine_fit</i> (params[, crit])	Refine the flat-field fit by minimizing data spread.
<i>nl_domain</i> (N, low, high)	Create the input domain where the non-linear correction defined.
<i>nl_lut</i> (domain, dy)	Compute the non-linear correction.
<i>nl_crit</i> (p, domain, alpha, arr_dark, arr, tid, rois, ...)	Criteria for the non linear correction.
<i>nl_crit_sk</i> (p, domain, alpha, arr_dark, arr, tid, rois, ...)	Non linear correction criteria, combining 'n' and 'p' as reference.
<i>nl_fit</i> (params, domain[, ff, crit])	Fit non linearities correction function.
<i>inspect_nl_fit</i> (res_fit)	Plot the progress of the fit.
<i>snr</i> (sig, ref[, methods, verbose])	Compute mean, std and SNR from transmitted and I0 signals.
<i>inspect_Fnl</i> (Fnl)	Plot the correction function Fnl.
<i>inspect_correction</i> (params[, gain])	Comparison plot of the different corrections.
<i>inspect_correction_sk</i> (params, ff[, gain])	Comparison plot of the different corrections, combining 'n' and 'p'.
<i>load_dssc_module</i> (proposalNB, runNB[, moduleNB, ...])	Load single module dssc data as dask array.
<i>average_module</i> (arr[, dark, ret, mask, sat_roi, ...])	Compute the average or std over a module.
<i>process_module</i> (arr, tid, dark, rois[, mask, ...])	Process one module and extract roi intensity.
<i>process</i> (Fmodel, arr_dark, arr, tid, rois, mask, flat_field)	Process dark and run data with corrections.
<i>inspect_saturation</i> (data, gain[, Nbins])	Plot roi integrated histogram of the data with saturation

**class** `toolbox_scs.routines.boz.parameters`(*proposal, darkrun, run, module, gain, drop\_intra\_darks=True*)

Parameters contains all input parameters for the BOZ corrections.

This is used in beam splitting off-axis zone plate spectroscopy analysis as well as the during the determination of

correction parameters themselves to ensure they can be reproduced.

### Inputs

proposal: int, proposal number  
darkrun: int, run number for the dark run  
run: int, run number for the data run  
module: int, DSSC module number  
gain: float, number of ph per bin  
drop\_intra\_darks: drop every second DSSC frame

**dask\_load\_persistently**(*dark\_data\_size\_Gb=None, data\_size\_Gb=None*)

Load dask data array in memory.

### Inputs

**dark\_data\_size\_Gb**: float, optional size of dark to load in memory, in Gb

**data\_size\_Gb**: float, optional size of data to load in memory, in Gb

**use\_gpu**()

**set\_mask**(*arr*)

Set mask of bad pixels.

### Inputs

**arr**: either a boolean array of a DSSC module image or a list of bad pixel indices

**get\_mask**()

Get the boolean array bad pixel of a DSSC module.

**get\_mask\_idx**()

Get the list of bad pixel indices.

**flat\_field\_guess**(*guess=None*)

Set the flat-field guess parameter for the fit and returns it.

### Inputs

**guess**: a list of 8 floats, the 4 first to define the plane

$ax+by+cz+d=0$  for 'n' beam and the 4 last for the 'p' beam in case mirror symmetry is disabled

**set\_flat\_field**(*ff\_params, ff\_type='plane', prod\_th=None, ratio\_th=None*)

Set the flat-field plane definition.

**Inputs**

ff\_params: list of parameters  
 ff\_type: string identifying the type of flat field normalization,  
 default is 'plane'.

**get\_flat\_field()**

Get the flat-field plane definition.

**set\_Fnl(Fnl)**

Set the non-linear correction function.

**get\_Fnl()**

Get the non-linear correction function.

**save(path='./')**

Save the parameters as a JSON file.

**Inputs**

path: str, where to save the file, default to './'

**classmethod load(fname)**

Load parameters from a JSON file.

**Inputs**

fname: string, name a the JSON file to load

**\_\_str\_\_()**

Return str(self).

`toolbox_scs.routines.boz.get_roi_pixel_pos(roi, params)`

Compute fake or real pixel position of an roi from roi center.

**Inputs:**

roi: dictionary  
 params: parameters

**Returns:**

X, Y: 1-d array of pixel position.

`toolbox_scs.routines.boz.bad_pixel_map(params)`

Compute the bad pixels map.

### Inputs

params: parameters

**rtype**

bad pixel map

`toolbox_scs.routines.boz.inspect_dark(arr, mean_th=(None, None), std_th=(None, None))`

Inspect dark run data and plot diagnostic.

### Inputs

arr: dask array of reshaped dssc data (trainId, pulseId, x, y) mean\_th: tuple of threshold (low, high), default (None, None), to compute

a mask of good pixels for which the mean dark value lie inside this range

**std\_th: tuple of threshold (low, high), default (None, None), to compute a**

mask of bad pixels for which the dark std value lie inside this range

**returns**

fig

**rtype**

matplotlib figure

`toolbox_scs.routines.boz.histogram_module(arr, mask=None)`

Compute a histogram of the 9 bits raw pixel values over a module.

### Inputs

arr: dask array of reshaped dssc data (trainId, pulseId, x, y) mask: optional bad pixel mask

**rtype**

histogram

`toolbox_scs.routines.boz.inspect_histogram(arr, arr_dark=None, mask=None, extra_lines=False)`

Compute and plot a histogram of the 9 bits raw pixel values.

### Inputs

arr: dask array of reshaped dssc data (trainId, pulseId, x, y) arr: dask array of reshaped dssc dark data (trainId, pulseId, x, y) mask: optional bad pixel mask extra\_lines: boolean, default False, plot extra lines at period values

**returns**

- **(h, hd)** (*histogram of arr, arr\_dark*)
- *figure*

`toolbox_scs.routines.boz.find_rois(data_mean, threshold, extended=False)`

Find rois from 3 beams configuration.

### Inputs

`data_mean`: dark corrected average image  
`threshold`: threshold value to find beams  
`extended`: boolean, True to define additional ASICS based rois

**returns**  
**rois**

**rtype**  
 dictionary of rois

`toolbox_scs.routines.boz.find_rois_from_params(params)`

Find rois from 3 beams configuration.

### Inputs

`params`: parameters

**returns**  
**rois**

**rtype**  
 dictionary of rois

`toolbox_scs.routines.boz.inspect_rois(data_mean, rois, threshold=None, allrois=False)`

Find rois from 3 beams configuration from mean module image.

### Inputs

`data_mean`: mean module image  
`threshold`: float, default None, threshold value used to detect beams  
 boundaries

**allrois**: boolean, default False, plot all rois defined in rois or only the main ones (['n', '0', 'p'])

**rtype**  
 matplotlib figure

`toolbox_scs.routines.boz.compute_flat_field_correction(rois, params, plot=False)`

`toolbox_scs.routines.boz.inspect_flat_field_domain(avg, rois, prod_th, ratio_th, vmin=None, vmax=None)`

Extract beams roi from average image and compute the ratio.

## Inputs

**avg:** module average image with no saturated shots for the flat-field determination

**rois:** dictionary or ROIs **prod\_th, ratio\_th:** tuple of floats for low and high threshold on product and ratio

**vmin:** imshow vmin level, default None will use 5 percentile value **vmax:** imshow vmax level, default None will use 99.8 percentile value

### returns

- **fig** (*matplotlib figure plotted*)
- **domain** (*a tuple (n\_m, p\_m) of domain for the 'n' and 'p' order*)

`toolbox_scs.routines.boz.inspect_plane_fitting(avg, rois, domain=None, vmin=None, vmax=None)`

`toolbox_scs.routines.boz.plane_fitting_domain(avg, rois, prod_th, ratio_th)`

Extract beams roi, compute their ratio and the domain.

## Inputs

**avg:** module average image with no saturated shots for the flat-field determination

**rois:** dictionary or rois containing the 3 beams ['n', '0', 'p'] with '0' as the reference beam in the middle

**prod\_th:** float tuple, low and high threshold level to determine the plane fitting domain on the product image of the orders

**ratio\_th:** float tuple, low and high threshold level to determine the plane fitting domain on the ratio image of the orders

### returns

- **n** (*img ratio 'n'/'0'*)
- **n\_m** (*mask where the the product 'n''0' is higher than 5 indicating that the\* – img ratio 'n'/'0' is defined*)
- **p** (*img ratio 'p'/'0'*)
- **p\_m** (*mask where the the product 'p''0' is higher than 5 indicating that the\* – img ratio 'p'/'0' is defined*)

`toolbox_scs.routines.boz.plane_fitting(params)`

Fit the plane flat-field normalization.

## Inputs

params: parameters

### returns

**res** – defines the plane as  $a*x + b*y + c*z + d = 0$

### rtype

the minimization result. The fitted vector  $res.x = [a, b, c, d]$

`toolbox_scs.routines.boz.ff_refine_crit(p, alpha, params, arr_dark, arr, tid, rois, mask, sat_level=511)`

Criteria for the `ff_refine_fit`.

## Inputs

p: ff plane params: parameters arr\_dark: dark data arr: data tid: train id of arr data rois: ['n', '0', 'p', 'sat'] rois  
mask: mask fo good pixels sat\_level: integer, default 511, at which level pixel begin to saturate

### rtype

sum of standard deviation on binned 0th order intensity

`toolbox_scs.routines.boz.ff_refine_fit(params, crit=ff_refine_crit)`

Refine the flat-field fit by minimizing data spread.

## Inputs

params: parameters

### returns

- **res** (*scipy minimize result. res.x is the optimized parameters*)
- **fitres** (*iteration index arrays of criteria results for*) – [alpha=0, alpha, alpha=1]

`toolbox_scs.routines.boz.nl_domain(N, low, high)`

Create the input domain where the non-linear correction defined.

## Inputs

N: integer, number of control points or intervals low: input values below or equal to low will not be corrected  
high: input values higher or equal to high will not be corrected

### rtype

array of  $2*9$  integer values with N segments

`toolbox_scs.routines.boz.nl_lut(domain, dy)`

Compute the non-linear correction.

## Inputs

**domain:** input domain where **dy** is defined. For zero no correction is defined. For non-zero value  $x$ ,  $dy[x]$  is applied.

**dy:** a vector of deviation from linearity on control point homogeneously dispersed over 9 bits.

### returns

**F\_INL** – lookup table with 9 bits integer input

### rtype

default None, non linear correction function given as a

`toolbox_scs.routines.boz.nl_crit(p, domain, alpha, arr_dark, arr, tid, rois, mask, flat_field, sat_level=511, use_gpu=False)`

Criteria for the non linear correction.

## Inputs

**p:** vector of **dy** non linear correction domain: domain over which the non linear correction is defined **alpha:** float, coefficient scaling the cost of the correction function

in the criterion

**arr\_dark:** dark data **arr:** data **tid:** train id of arr data **rois:** ['n', '0', 'p', 'sat'] **rois mask:** mask fo good pixels **flat\_field:** zone plate flat-field correction **sat\_level:** integer, default 511, at which level pixel begin to saturate

### returns

- $(1.0 - \alpha) * err1 + \alpha * err2$ , where *err1* is the  $1e8$  times the mean of
- error squared from a transmission of 1.0 and *err2* is the sum of the square
- of the deviation from the ideal detector response.

`toolbox_scs.routines.boz.nl_crit_sk(p, domain, alpha, arr_dark, arr, tid, rois, mask, flat_field, sat_level=511, use_gpu=False)`

Non linear correction criteria, combining 'n' and 'p' as reference.

## Inputs

**p:** vector of **dy** non linear correction domain: domain over which the non linear correction is defined **alpha:** float, coefficient scaling the cost of the correction function

in the criterion

**arr\_dark:** dark data **arr:** data **tid:** train id of arr data **rois:** ['n', '0', 'p', 'sat'] **rois mask:** mask fo good pixels **flat\_field:** zone plate flat-field correction **sat\_level:** integer, default 511, at which level pixel begin to saturate

### returns

- $(1.0 - \alpha) * err1 + \alpha * err2$ , where *err1* is the  $1e8$  times the mean of
- error squared from a transmission of 1.0 and *err2* is the sum of the square
- of the deviation from the ideal detector response.



`toolbox_scs.routines.boz.nl_fit(params, domain, ff=None, crit=None)`

Fit non linearities correction function.

### Inputs

params: parameters domain: array of index ff: array, flat field correction crit: function, criteria function

#### returns

- **res** (*scipy minimize result. res.x is the optimized parameters*)
- **fitres** (*iteration index arrays of criteria results for*) – [alpha=0, alpha, alpha=1]

`toolbox_scs.routines.boz.inspect_nl_fit(res_fit)`

Plot the progress of the fit.

### Inputs

res\_fit:

#### rtype

matplotlib figure

`toolbox_scs.routines.boz.snr(sig, ref, methods=None, verbose=False)`

Compute mean, std and SNR from transmitted and IO signals.

### Inputs

sig: 1D signal samples ref: 1D reference samples methods: None by default or list of strings to select which methods to use.

Possible values are 'direct', 'weighted', 'diff'. In case of None, all methods will be calculated.

verbose: boolean, if True prints calculated values

#### returns

- *dictionary of [methods][value] where value is 'mu' for mean and 's' for*
- *standard deviation.*

`toolbox_scs.routines.boz.inspect_Fnl(Fnl)`

Plot the correction function Fnl.

### Inputs

Fnl: non linear correction function lookup table

#### rtype

matplotlib figure

`toolbox_scs.routines.boz.inspect_correction(params, gain=None)`

Comparison plot of the different corrections.

### Inputs

params: parameters gain: float, default None, DSSC gain in ph/bin

#### rtype

matplotlib figure

`toolbox_scs.routines.boz.inspect_correction_sk(params, ff, gain=None)`

Comparison plot of the different corrections, combining 'n' and 'p'.

### Inputs

params: parameters gain: float, default None, DSSC gain in ph/bin

#### rtype

matplotlib figure

`toolbox_scs.routines.boz.load_dssc_module(proposalNB, runNB, moduleNB=15, subset=slice(None), drop_intra_darks=True, persist=False, data_size_Gb=None)`

Load single module dssc data as dask array.

### Inputs

proposalNB: proposal number runNB: run number moduleNB: default 15, module number subset: default slice(None), subset of trains to load drop\_intra\_darks: boolean, default True, remove intra darks from the data persist: default False, load all data persistently in memory data\_size\_Gb: float, if persist is True, can optionally restrict

the amount of data loaded for dark data and run data in Gb

#### returns

- **arr** (dask array of reshaped dssc data (trainId, pulseId, x, y))
- **tid** (array of train id number)

`toolbox_scs.routines.boz.average_module(arr, dark=None, ret='mean', mask=None, sat_roi=None, sat_level=300, F_INL=None)`

Compute the average or std over a module.

### Inputs

arr: dask array of reshaped dssc data (trainId, pulseId, x, y) dark: default None, dark to be subtracted ret: string, either 'mean' to compute the mean or 'std' to compute the

standard deviation

mask: default None, mask of bad pixels to ignore sat\_roi: roi over which to check for pixel with values larger than

sat\_level to drop the image from the average or std

sat\_level: int, minimum pixel value for a pixel to be considered saturated F\_INL: default None, non linear correction function given as a

lookup table with 9 bits integer input

**rtype**

average or standard deviation image

```
toolbox_scs.routines.boz.process_module(arr, tid, dark, rois, mask=None, sat_level=511, flat_field=None,
                                          F_INL=None, use_gpu=False)
```

Process one module and extract roi intensity.

**Inputs**

arr: dask array of reshaped dssc data (trainId, pulseId, x, y) tid: array of train id number dark: pulse resolved dark image to remove rois: dictionary of rois mask: default None, mask of ignored pixels sat\_level: integer, default 511, at which level pixel begin to saturate flat\_field: default None, flat-field correction F\_INL: default None, non-linear correction function given as a

lookup table with 9 bits integer input

**rtype**

dataset of extracted pulse and train resolved roi intensities.

```
toolbox_scs.routines.boz.process(Fmodel, arr_dark, arr, tid, rois, mask, flat_field, sat_level=511,
                                  use_gpu=False)
```

Process dark and run data with corrections.

**Inputs**

Fmodel: correction lookup table arr\_dark: dark data arr: data rois: ['n', '0', 'p', 'sat'] rois mask: mask of good pixels flat\_field: zone plate flat-field correction sat\_level: integer, default 511, at which level pixel begin to saturate

**rtype**

roi extracted intensities

```
toolbox_scs.routines.boz.inspect_saturation(data, gain, Nbins=200)
```

Plot roi integrated histogram of the data with saturation

**Inputs**

data: xarray of roi integrated DSSC data gain: nominal DSSC gain in ph/bin Nbins: number of bins for the histogram, by default 200

**returns**

- **f** (*handle to the matplotlib figure*)
- **h** (*xarray of the histogram data*)

### `toolbox_scs.routines.knife_edge`

Toolbox for SCS.

Various utilities function to quickly process data measured at the SCS instrument.

Copyright (2019-) SCS Team.

## Module Contents

### Functions

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<code>knife_edge(ds[, axisKey, signalKey, axisRange, p0, ...])</code>	Calculates the beam radius at $1/e^2$ from a knife-edge scan by
---	---

---

`toolbox_scs.routines.knife_edge.knife_edge(ds, axisKey='scannerX', signalKey='FastADC4peaks', axisRange=None, p0=None, full=False, plot=False, display=False)`

Calculates the beam radius at  $1/e^2$  from a knife-edge scan by fitting with erfc function:  $f(x, x0, w0, a, b) = a * \text{erfc}(\text{np.sqrt}(2) * (x - x0) / w0) + b$  with  $w0$  the beam radius at  $1/e^2$  and  $x0$  the beam center.

#### Parameters

- **ds** (*xarray Dataset*) – dataset containing the detector signal and the motor position.
- **axisKey** (*str*) – key of the axis against which the knife-edge is performed.
- **signalKey** (*str*) – key of the detector signal.
- **axisRange** (*list of floats*) – edges of the scanning axis between which to apply the fit.
- **p0** (*list of floats, numpy 1D array*) – initial parameters used for the fit:  $x0$ ,  $w0$ ,  $a$ ,  $b$ . If None, a beam radius of 100 micrometers is assumed.
- **full** (*bool*) – If False, returns the beam radius and standard error. If True, returns the `popt`, `pcov` list of parameters and covariance matrix from `scipy.optimize.curve_fit`.
- **plot** (*bool*) – If True, plots the data and the result of the fit. Default is False.
- **display** (*bool*) – If True, displays info on the fit. True when plot is True, default is False.

#### Returns

error from the fit in mm. If `full` is True, returns parameters and covariance matrix from `scipy.optimize.curve_fit` function.

#### Return type

If `full` is False, tuple with beam radius at  $1/e^2$  in mm and standard

## Package Contents

### Classes

<i>parameters</i>	Parameters contains all input parameters for the BOZ corrections.
-------------------	---

### Functions

<i>xas</i> (nrun[, bins, lokey, ltkey, nrjkey, loffset, ...])	Compute the XAS spectra from a xarray nrun.
<i>xasxmc</i> (dataP, dataN)	Compute XAS and XMCD from data with both magnetic field direction
<i>get_roi_pixel_pos</i> (roi, params)	Compute fake or real pixel position of an roi from roi center.
<i>bad_pixel_map</i> (params)	Compute the bad pixels map.
<i>inspect_dark</i> (arr[, mean_th, std_th])	Inspect dark run data and plot diagnostic.
<i>histogram_module</i> (arr[, mask])	Compute a histogram of the 9 bits raw pixel values over a module.
<i>inspect_histogram</i> (arr[, arr_dark, mask, extra_lines])	Compute and plot a histogram of the 9 bits raw pixel values.
<i>find_rois</i> (data_mean, threshold[, extended])	Find rois from 3 beams configuration.
<i>find_rois_from_params</i> (params)	Find rois from 3 beams configuration.
<i>inspect_rois</i> (data_mean, rois[, threshold, allrois])	Find rois from 3 beams configuration from mean module image.
<i>compute_flat_field_correction</i> (rois, params[, plot])	
<i>inspect_flat_field_domain</i> (avg, rois, prod_th, ratio_th)	Extract beams roi from average image and compute the ratio.
<i>inspect_plane_fitting</i> (avg, rois[, domain, vmin, vmax])	
<i>plane_fitting_domain</i> (avg, rois, prod_th, ratio_th)	Extract beams roi, compute their ratio and the domain.
<i>plane_fitting</i> (params)	Fit the plane flat-field normalization.
<i>ff_refine_crit</i> (p, alpha, params, arr_dark, arr, tid, ...)	Criteria for the ff_refine_fit.
<i>ff_refine_fit</i> (params[, crit])	Refine the flat-field fit by minimizing data spread.
<i>nl_domain</i> (N, low, high)	Create the input domain where the non-linear correction defined.
<i>nl_lut</i> (domain, dy)	Compute the non-linear correction.
<i>nl_crit</i> (p, domain, alpha, arr_dark, arr, tid, rois, ...)	Criteria for the non linear correction.
<i>nl_crit_sk</i> (p, domain, alpha, arr_dark, arr, tid, rois, ...)	Non linear correction criteria, combining 'n' and 'p' as reference.
<i>nl_fit</i> (params, domain[, ff, crit])	Fit non linearities correction function.
<i>inspect_nl_fit</i> (res_fit)	Plot the progress of the fit.
<i>snr</i> (sig, ref[, methods, verbose])	Compute mean, std and SNR from transmitted and I0 signals.
<i>inspect_Fnl</i> (Fnl)	Plot the correction function Fnl.
<i>inspect_correction</i> (params[, gain])	Comparison plot of the different corrections.
<i>inspect_correction_sk</i> (params, ff[, gain])	Comparison plot of the different corrections, combining 'n' and 'p'.

continues on next page

Table 1 – continued from previous page

<code>load_dssc_module</code> (proposalNB, runNB[, moduleNB, ...])	Load single module dssc data as dask array.
<code>average_module</code> (arr[, dark, ret, mask, sat_roi, ...])	Compute the average or std over a module.
<code>process_module</code> (arr, tid, dark, rois[, mask, ...])	Process one module and extract roi intensity.
<code>process</code> (Fmodel, arr_dark, arr, tid, rois, mask, flat_field)	Process dark and run data with corrections.
<code>inspect_saturation</code> (data, gain[, Nbins])	Plot roi integrated histogram of the data with saturation
<code>reflectivity</code> (data[, Iokey, Irkey, delaykey, binWidth, ...])	Computes the reflectivity $R = 100 * (I_r / I_o[\text{pumped}] / I_r / I_o[\text{unpumped}] - 1)$
<code>knife_edge</code>	Toolbox for SCS.

## Attributes

---

`__all__`

---

`toolbox_scs.routines.xas`(*nrun*, *bins=None*, *Iokey='SCS\_SA3'*, *Itkey='MCP3peaks'*, *nrjkey='nrj'*, *Iooffset=0*, *plot=False*, *fluorescence=False*)

Compute the XAS spectra from a xarray nrun.

### Inputs:

*nrun*: xarray of SCS data  
*bins*: an array of bin-edges or an integer number of desired bins or a float for the desired bin width.

*Iokey*: string for the Io fields, typically 'SCS\_XGM'  
*Itkey*: string for the It fields, typically 'MCP3apd'  
*nrjkey*: string for the nrj fields, typically 'nrj'  
*Iooffset*: offset to apply on Io plot: boolean, displays a XAS spectrum if True  
*fluorescence*: boolean, if True, absorption is the ratio,

if False, absorption is negative log

### Outputs:

#### a dictionary containing:

*nrj*: the bin centers  
*muA*: the absorption  
*sigmaA*: standard deviation on the absorption  
*sterrA*: standard error on the absorption  
*muIo*: the mean of the Io counts  
the number of events in each bin

`toolbox_scs.routines.xasxmcd`(*dataP*, *dataN*)

Compute XAS and XMCD from data with both magnetic field direction Inputs:

*dataP*: structured array for positive field  
*dataN*: structured array for negative field

### Outputs:

*xas*: structured array for the sum  
*xmcd*: structured array for the difference

**class** `toolbox_scs.routines.parameters`(*proposal*, *darkrun*, *run*, *module*, *gain*, *drop\_intra\_darks=True*)

Parameters contains all input parameters for the BOZ corrections.

This is used in beam splitting off-axis zone plate spectroscopy analysis as well as the during the determination of correction parameters themselves to ensure they can be reproduced.

## Inputs

proposal: int, proposal number  
 darkrun: int, run number for the dark run  
 run: int, run number for the data run  
 module: int, DSSC module number  
 gain: float, number of ph per bin  
 drop\_intra\_darks: drop every second DSSC frame

**dask\_load\_persistently**(*dark\_data\_size\_Gb=None, data\_size\_Gb=None*)

Load dask data array in memory.

## Inputs

**dark\_data\_size\_Gb**: float, optional size of dark to load in memory, in Gb

**data\_size\_Gb**: float, optional size of data to load in memory, in Gb

**use\_gpu**()

**set\_mask**(*arr*)

Set mask of bad pixels.

## Inputs

**arr**: either a boolean array of a DSSC module image or a list of bad pixel indices

**get\_mask**()

Get the boolean array bad pixel of a DSSC module.

**get\_mask\_idx**()

Get the list of bad pixel indices.

**flat\_field\_guess**(*guess=None*)

Set the flat-field guess parameter for the fit and returns it.

## Inputs

**guess**: a list of 8 floats, the 4 first to define the plane

$ax+by+cz+d=0$  for 'n' beam and the 4 last for the 'p' beam in case mirror symmetry is disabled

**set\_flat\_field**(*ff\_params, ff\_type='plane', prod\_th=None, ratio\_th=None*)

Set the flat-field plane definition.

### Inputs

ff\_params: list of parameters  
ff\_type: string identifying the type of flat field normalization,  
default is 'plane'.

#### **get\_flat\_field()**

Get the flat-field plane definition.

#### **set\_Fnl(Fnl)**

Set the non-linear correction function.

#### **get\_Fnl()**

Get the non-linear correction function.

#### **save(path='./')**

Save the parameters as a JSON file.

### Inputs

path: str, where to save the file, default to './'

#### **classmethod load(fname)**

Load parameters from a JSON file.

### Inputs

fname: string, name a the JSON file to load

#### **\_\_str\_\_()**

Return str(self).

`toolbox_scs.routines.get_roi_pixel_pos(roi, params)`

Compute fake or real pixel position of an roi from roi center.

### Inputs:

roi: dictionary  
params: parameters

### Returns:

X, Y: 1-d array of pixel position.

`toolbox_scs.routines.bad_pixel_map(params)`

Compute the bad pixels map.



### Inputs

params: parameters

**rtype**  
bad pixel map

`toolbox_scs.routines.inspect_dark(arr, mean_th=(None, None), std_th=(None, None))`

Inspect dark run data and plot diagnostic.

### Inputs

arr: dask array of reshaped dssc data (trainId, pulseId, x, y) mean\_th: tuple of threshold (low, high), default (None, None), to compute

a mask of good pixels for which the mean dark value lie inside this range

**std\_th: tuple of threshold (low, high), default (None, None), to compute a**

mask of bad pixels for which the dark std value lie inside this range

**returns**  
**fig**

**rtype**  
matplotlib figure

`toolbox_scs.routines.histogram_module(arr, mask=None)`

Compute a histogram of the 9 bits raw pixel values over a module.

### Inputs

arr: dask array of reshaped dssc data (trainId, pulseId, x, y) mask: optional bad pixel mask

**rtype**  
histogram

`toolbox_scs.routines.inspect_histogram(arr, arr_dark=None, mask=None, extra_lines=False)`

Compute and plot a histogram of the 9 bits raw pixel values.

### Inputs

arr: dask array of reshaped dssc data (trainId, pulseId, x, y) arr\_dark: dask array of reshaped dssc dark data (trainId, pulseId, x, y) mask: optional bad pixel mask extra\_lines: boolean, default False, plot extra lines at period values

**returns**

- **(h, hd)** (*histogram of arr, arr\_dark*)
- *figure*

`toolbox_scs.routines.find_rois(data_mean, threshold, extended=False)`

Find rois from 3 beams configuration.

### Inputs

`data_mean`: dark corrected average image  
`threshold`: threshold value to find beams  
`extended`: boolean, True to define additional ASICS based rois

**returns**  
**rois**

**rtype**  
dictionary of rois

`toolbox_scs.routines.find_rois_from_params(params)`

Find rois from 3 beams configuration.

### Inputs

`params`: parameters

**returns**  
**rois**

**rtype**  
dictionary of rois

`toolbox_scs.routines.inspect_rois(data_mean, rois, threshold=None, allrois=False)`

Find rois from 3 beams configuration from mean module image.

### Inputs

`data_mean`: mean module image  
`threshold`: float, default None, threshold value used to detect beams  
boundaries

**allrois**: boolean, default False, plot all rois defined in rois or only the main ones (['n', '0', 'p'])

**rtype**  
matplotlib figure

`toolbox_scs.routines.compute_flat_field_correction(rois, params, plot=False)`

`toolbox_scs.routines.inspect_flat_field_domain(avg, rois, prod_th, ratio_th, vmin=None, vmax=None)`

Extract beams roi from average image and compute the ratio.

### Inputs

**avg**: module average image with no saturated shots for the flat-field determination

`rois`: dictionary or ROIs  
`prod_th`, `ratio_th`: tuple of floats for low and high threshold on product and ratio

`vmin`: imshow vmin level, default None will use 5 percentile value  
`vmax`: imshow vmax level, default None will use 99.8 percentile value

**returns**

- **fig** (*matplotlib figure plotted*)
- **domain** (*a tuple (n\_m, p\_m) of domain for the 'n' and 'p' order*)

`toolbox_scs.routines.inspect_plane_fitting`(*avg, rois, domain=None, vmin=None, vmax=None*)

`toolbox_scs.routines.plane_fitting_domain`(*avg, rois, prod\_th, ratio\_th*)

Extract beams roi, compute their ratio and the domain.

**Inputs**

**avg**: **module average image with no saturated shots for the flat-field determination**

**rois**: **dictionnary or rois containing the 3 beams ['n', '0', 'p'] with '0' as the reference beam in the middle**

**prod\_th**: **float tuple, low and high threshold level to determine the plane fitting domain on the product image of the orders**

**ratio\_th**: **float tuple, low and high threshold level to determine the plane fitting domain on the ratio image of the orders**

**returns**

- **n** (*img ratio 'n'/0*)
- **n\_m** (*mask where the the product 'n'0 is higher than 5 indicting that the\* – img ratio 'n'/0 is defined*)
- **p** (*img ratio 'p'/0*)
- **p\_m** (*mask where the the product 'p'0 is higher than 5 indicting that the\* – img ratio 'p'/0 is defined*)

`toolbox_scs.routines.plane_fitting`(*params*)

Fit the plane flat-field normalization.

**Inputs**

params: parameters

**returns**

**res** – defines the plane as  $a*x + b*y + c*z + d = 0$

**rtype**

the minimization result. The fitted vector  $res.x = [a, b, c, d]$

`toolbox_scs.routines.ff_refine_crit`(*p, alpha, params, arr\_dark, arr, tid, rois, mask, sat\_level=511*)

Criteria for the `ff_refine_fit`.

### Inputs

p: ff plane params: parameters arr\_dark: dark data arr: data tid: train id of arr data rois: ['n', '0', 'p', 'sat'] rois  
mask: mask fo good pixels sat\_level: integer, default 511, at which level pixel begin to saturate

#### rtype

sum of standard deviation on binned 0th order intensity

`toolbox_scs.routines.ff_refine_fit(params, crit=ff_refine_crit)`

Refine the flat-field fit by minimizing data spread.

### Inputs

params: parameters

#### returns

- **res** (*scipy minimize result. res.x is the optimized parameters*)
- **fitrres** (*iteration index arrays of criteria results for*) – [alpha=0, alpha, alpha=1]

`toolbox_scs.routines.nl_domain(N, low, high)`

Create the input domain where the non-linear correction defined.

### Inputs

N: integer, number of control points or intervals low: input values below or equal to low will not be corrected  
high: input values higher or equal to high will not be corrected

#### rtype

array of 2\*\*9 integer values with N segments

`toolbox_scs.routines.nl_lut(domain, dy)`

Compute the non-linear correction.

### Inputs

**domain: input domain where dy is defined. For zero no correction is**  
defined. For non-zero value x, dy[x] is applied.

**dy: a vector of deviation from linearity on control point homogeneously**  
dispersed over 9 bits.

#### returns

**F\_INL** – lookup table with 9 bits integer input

#### rtype

default None, non linear correction function given as a

`toolbox_scs.routines.nl_crit(p, domain, alpha, arr_dark, arr, tid, rois, mask, flat_field, sat_level=511,  
use_gpu=False)`

Criteria for the non linear correction.

## Inputs

p: vector of dy non linear correction domain: domain over which the non linear correction is defined alpha: float, coefficient scaling the cost of the correction function

in the criterion

arr\_dark: dark data arr: data tid: train id of arr data rois: ['n', '0', 'p', 'sat'] rois mask: mask fo good pixels flat\_field: zone plate flat-field correction sat\_level: integer, default 511, at which level pixel begin to saturate

### returns

- $(1.0 - \alpha) * err1 + \alpha * err2$ , where *err1* is the  $1e8$  times the mean of
- error squared from a transmission of 1.0 and *err2* is the sum of the square
- of the deviation from the ideal detector response.

`toolbox_scs.routines.nl_crit_sk(p, domain, alpha, arr_dark, arr, tid, rois, mask, flat_field, sat_level=511, use_gpu=False)`

Non linear correction criteria, combining 'n' and 'p' as reference.

## Inputs

p: vector of dy non linear correction domain: domain over which the non linear correction is defined alpha: float, coefficient scaling the cost of the correction function

in the criterion

arr\_dark: dark data arr: data tid: train id of arr data rois: ['n', '0', 'p', 'sat'] rois mask: mask fo good pixels flat\_field: zone plate flat-field correction sat\_level: integer, default 511, at which level pixel begin to saturate

### returns

- $(1.0 - \alpha) * err1 + \alpha * err2$ , where *err1* is the  $1e8$  times the mean of
- error squared from a transmission of 1.0 and *err2* is the sum of the square
- of the deviation from the ideal detector response.

`toolbox_scs.routines.nl_fit(params, domain, ff=None, crit=None)`

Fit non linearities correction function.

## Inputs

params: parameters domain: array of index ff: array, flat field correction crit: function, criteria function

### returns

- **res** (*scipy minimize result. res.x is the optimized parameters*)
- **fitres** (*iteration index arrays of criteria results for*) – [alpha=0, alpha, alpha=1]

`toolbox_scs.routines.inspect_nl_fit(res_fit)`

Plot the progress of the fit.

### Inputs

res\_fit:

**rtype**

matplotlib figure

`toolbox_scs.routines.snr(sig, ref, methods=None, verbose=False)`

Compute mean, std and SNR from transmitted and IO signals.

### Inputs

sig: 1D signal samples ref: 1D reference samples methods: None by default or list of strings to select which methods to use.

Possible values are 'direct', 'weighted', 'diff'. In case of None, all methods will be calculated.

verbose: boolean, if True prints calculated values

**returns**

- dictionary of [methods][value] where value is 'mu' for mean and 's' for standard deviation.

`toolbox_scs.routines.inspect_Fnl(Fnl)`

Plot the correction function Fnl.

### Inputs

Fnl: non linear correction function lookup table

**rtype**

matplotlib figure

`toolbox_scs.routines.inspect_correction(params, gain=None)`

Comparison plot of the different corrections.

### Inputs

params: parameters gain: float, default None, DSSC gain in ph/bin

**rtype**

matplotlib figure

`toolbox_scs.routines.inspect_correction_sk(params, ff, gain=None)`

Comparison plot of the different corrections, combining 'n' and 'p'.

## Inputs

params: parameters gain: float, default None, DSSC gain in ph/bin

### rtype

matplotlib figure

```
toolbox_scs.routines.load_dssc_module(proposalNB, runNB, moduleNB=15, subset=slice(None),
                                     drop_intra_darks=True, persist=False, data_size_Gb=None)
```

Load single module dssc data as dask array.

## Inputs

proposalNB: proposal number runNB: run number moduleNB: default 15, module number subset: default slice(None), subset of trains to load drop\_intra\_darks: boolean, default True, remove intra darks from the data persist: default False, load all data persistently in memory data\_size\_Gb: float, if persist is True, can optionally restrict

the amount of data loaded for dark data and run data in Gb

### returns

- **arr** (dask array of reshaped dssc data (trainId, pulseId, x, y))
- **tid** (array of train id number)

```
toolbox_scs.routines.average_module(arr, dark=None, ret='mean', mask=None, sat_roi=None,
                                   sat_level=300, F_INL=None)
```

Compute the average or std over a module.

## Inputs

arr: dask array of reshaped dssc data (trainId, pulseId, x, y) dark: default None, dark to be subtracted ret: string, either 'mean' to compute the mean or 'std' to compute the

standard deviation

mask: default None, mask of bad pixels to ignore sat\_roi: roi over which to check for pixel with values larger than

sat\_level to drop the image from the average or std

sat\_level: int, minimum pixel value for a pixel to be considered saturated F\_INL: default None, non linear correction function given as a

lookup table with 9 bits integer input

### rtype

average or standard deviation image

```
toolbox_scs.routines.process_module(arr, tid, dark, rois, mask=None, sat_level=511, flat_field=None,
                                   F_INL=None, use_gpu=False)
```

Process one module and extract roi intensity.

## Inputs

arr: dask array of reshaped dssc data (trainId, pulseId, x, y) tid: array of train id number dark: pulse resolved dark image to remove rois: dictionary of rois mask: default None, mask of ignored pixels sat\_level: integer, default 511, at which level pixel begin to saturate flat\_field: default None, flat-field correction F\_INL: default None, non-linear correction function given as a

lookup table with 9 bits integer input

### rtype

dataset of extracted pulse and train resolved roi intensities.

```
toolbox_scs.routines.process(Fmodel, arr_dark, arr, tid, rois, mask, flat_field, sat_level=511,
                             use_gpu=False)
```

Process dark and run data with corrections.

## Inputs

Fmodel: correction lookup table arr\_dark: dark data arr: data rois: ['n', '0', 'p', 'sat'] rois mask: mask of good pixels flat\_field: zone plate flat-field correction sat\_level: integer, default 511, at which level pixel begin to saturate

### rtype

roi extracted intensities

```
toolbox_scs.routines.inspect_saturation(data, gain, Nbins=200)
```

Plot roi integrated histogram of the data with saturation

## Inputs

data: xarray of roi integrated DSSC data gain: nominal DSSC gain in ph/bin Nbins: number of bins for the histogram, by default 200

### returns

- **f** (*handle to the matplotlib figure*)
- **h** (*xarray of the histogram data*)

```
toolbox_scs.routines.reflectivity(data, Iokey='FastADC5peaks', Irkey='FastADC3peaks',
                                  delaykey='PP800_DelayLine', binWidth=0.05, positionToDelay=True,
                                  origin=None, invert=False, pumpedOnly=False, alternateTrains=False,
                                  pumpOnEven=True, lowweights=False, plot=True, plotErrors=True,
                                  units='mm')
```

Computes the reflectivity  $R = 100 * (I_r / I_o[\text{pumped}] / I_r / I_o[\text{unpumped}] - 1)$  as a function of delay. Delay can be a motor position in mm or an optical delay in ps, with possibility to convert from position to delay. The default scheme is alternating pulses pumped/unpumped/... in each train, also possible are alternating trains and pumped only. If fitting is enabled, attempts a double exponential (default) or step function fit.

### Parameters

- **data** (*xarray Dataset*) – Dataset containing the Io, Ir and delay data
- **Iokey** (*str*) – Name of the Io variable



- **Irkey** (*str*) – Name of the Ir variable
- **delaykey** (*str*) – Name of the delay variable (motor position in mm or optical delay in ps)
- **binWidth** (*float*) – width of bin in units of delay variable
- **positionToDelay** (*bool*) – If True, adds a time axis converted from position axis according to origin and invert parameters. Ignored if origin is None.
- **origin** (*float*) – Position of time overlap, shown as a vertical line. Used if positionToDelay is True to convert position to time axis.
- **invert** (*bool*) – Used if positionToDelay is True to convert position to time axis.
- **pumpedOnly** (*bool*) – Assumes that all trains and pulses are pumped. In this case, Delta R is defined as Ir/Io.
- **alternateTrains** (*bool*) – If True, assumes that trains alternate between pumped and unpumped data.
- **pumpOnEven** (*bool*) – Only used if alternateTrains=True. If True, even trains are pumped, if False, odd trains are pumped.
- **Ioweights** (*bool*) – If True, computes the ratio of the means instead of the mean of the ratios Irkey/Iokey. Useful when dealing with large intensity variations.
- **plot** (*bool*) – If True, plots the results.
- **plotErrors** (*bool*) – If True, plots the 95% confidence interval.
- **Output** –
  - ----- – xarray Dataset containing the binned Delta R, standard deviation, standard error, counts and delays, and the fitting results if full is True.

`toolbox_scs.routines.knife_edge(ds, axisKey='scannerX', signalKey='FastADC4peaks', axisRange=None, p0=None, full=False, plot=False, display=False)`

Calculates the beam radius at  $1/e^2$  from a knife-edge scan by fitting with erfc function:  $f(x, x0, w0, a, b) = a * \text{erfc}(\text{np.sqrt}(2) * (x-x0)/w0) + b$  with  $w0$  the beam radius at  $1/e^2$  and  $x0$  the beam center.

#### Parameters

- **ds** (*xarray Dataset*) – dataset containing the detector signal and the motor position.
- **axisKey** (*str*) – key of the axis against which the knife-edge is performed.
- **signalKey** (*str*) – key of the detector signal.
- **axisRange** (*list of floats*) – edges of the scanning axis between which to apply the fit.
- **p0** (*list of floats, numpy 1D array*) – initial parameters used for the fit:  $x0$ ,  $w0$ ,  $a$ ,  $b$ . If None, a beam radius of 100 micrometers is assumed.
- **full** (*bool*) – If False, returns the beam radius and standard error. If True, returns the `popt`, `pcov` list of parameters and covariance matrix from `scipy.optimize.curve_fit`.
- **plot** (*bool*) – If True, plots the data and the result of the fit. Default is False.
- **display** (*bool*) – If True, displays info on the fit. True when plot is True, default is False.

#### Returns

error from the fit in mm. If full is True, returns parameters and covariance matrix from `scipy.optimize.curve_fit` function.

### Return type

If full is False, tuple with beam radius at  $1/e^2$  in mm and standard

`toolbox_scs.routines.__all__`

`toolbox_scs.test`

### Submodules

`toolbox_scs.test.test_dssc_cls`

### Module Contents

#### Classes

---

<code>TestDSSC</code>	A class whose instances are single test cases.
-----------------------	--

---

#### Functions

---

`setup_tmp_dir()`

---

`cleanup_tmp_dir()`

---

`list_suites()`

---

`suite(*tests)`

---

`main(*cliargs)`

---

#### Attributes

---

`log_root`

---

`suites`

---

`_temp_dirs`

---

`parser`

---

`toolbox_scs.test.test_dssc_cls.log_root`

`toolbox_scs.test.test_dssc_cls.suites`

`toolbox_scs.test.test_dssc_cls._temp_dirs = ['tmp']`

```
toolbox_scs.test.test_dssc_cls.setup_tmp_dir()
```

```
toolbox_scs.test.test_dssc_cls.cleanup_tmp_dir()
```

```
class toolbox_scs.test.test_dssc_cls.TestDSSC(methodName='runTest')
```

Bases: unittest.TestCase

A class whose instances are single test cases.

By default, the test code itself should be placed in a method named 'runTest'.

If the fixture may be used for many test cases, create as many test methods as are needed. When instantiating such a TestCase subclass, specify in the constructor arguments the name of the test method that the instance is to execute.

Test authors should subclass TestCase for their own tests. Construction and deconstruction of the test's environment ('fixture') can be implemented by overriding the 'setUp' and 'tearDown' methods respectively.

If it is necessary to override the \_\_init\_\_ method, the base class \_\_init\_\_ method must always be called. It is important that subclasses should not change the signature of their \_\_init\_\_ method, since instances of the classes are instantiated automatically by parts of the framework in order to be run.

When subclassing TestCase, you can set these attributes: \* `failureException`: determines which exception will be raised when

the instance's assertion methods fail; test methods raising this exception will be deemed to have 'failed' rather than 'errored'.

- **longMessage**: determines whether long messages (including repr of objects used in assert methods) will be printed on failure in *addition* to any explicit message passed.
- **maxDiff**: sets the maximum length of a diff in failure messages by assert methods using `difflib`. It is looked up as an instance attribute so can be configured by individual tests if required.

```
classmethod setUpClass()
```

Hook method for setting up class fixture before running tests in the class.

```
classmethod tearDownClass()
```

Hook method for deconstructing the class fixture after running all tests in the class.

```
test_create()
```

```
test_use_xgm_tim()
```

```
test_processing_quick()
```

```
test_normalization_all()
```

```
toolbox_scs.test.test_dssc_cls.list_suites()
```

```
toolbox_scs.test.test_dssc_cls.suite(*tests)
```

```
toolbox_scs.test.test_dssc_cls.main(*cliargs)
```

```
toolbox_scs.test.test_dssc_cls.parser
```

`toolbox_scs.test.test_hrixs`

### Module Contents

#### Classes

---

*TestHRIXS*

A class whose instances are single test cases.

---

**class** `toolbox_scs.test.test_hrixs.TestHRIXS`(*methodName='runTest'*)

Bases: `unittest.TestCase`

A class whose instances are single test cases.

By default, the test code itself should be placed in a method named 'runTest'.

If the fixture may be used for many test cases, create as many test methods as are needed. When instantiating such a `TestCase` subclass, specify in the constructor arguments the name of the test method that the instance is to execute.

Test authors should subclass `TestCase` for their own tests. Construction and deconstruction of the test's environment ('fixture') can be implemented by overriding the 'setUp' and 'tearDown' methods respectively.

If it is necessary to override the `__init__` method, the base class `__init__` method must always be called. It is important that subclasses should not change the signature of their `__init__` method, since instances of the classes are instantiated automatically by parts of the framework in order to be run.

When subclassing `TestCase`, you can set these attributes: \* `failureException`: determines which exception will be raised when

the instance's assertion methods fail; test methods raising this exception will be deemed to have 'failed' rather than 'errored'.

- **longMessage**: determines whether long messages (including repr of objects used in assert methods) will be printed on failure in *addition* to any explicit message passed.
- **maxDiff**: sets the maximum length of a diff in failure messages by assert methods using `difflib`. It is looked up as an instance attribute so can be configured by individual tests if required.

`test_integration()`

`test_centroid()`

`test_getparam()`

`toolbox_scs.test.test_misc`

### Module Contents

#### Classes

---

*TestDataAccess*

A class whose instances are single test cases.

---

## Functions

---

*list\_suites()*

---

*suite(\*tests)*

---

*start\_tests(\*cliargs)*

---

## Attributes

---

*proposalNB*

---

*runNB*

---

*suites*

---

*parser*

---

`toolbox_scs.test.test_misc.proposalNB = 2511`

`toolbox_scs.test.test_misc.runNB = 176`

`toolbox_scs.test.test_misc.suites`

**class** `toolbox_scs.test.test_misc.TestDataAccess`(*methodName='runTest'*)

Bases: `unittest.TestCase`

A class whose instances are single test cases.

By default, the test code itself should be placed in a method named 'runTest'.

If the fixture may be used for many test cases, create as many test methods as are needed. When instantiating such a `TestCase` subclass, specify in the constructor arguments the name of the test method that the instance is to execute.

Test authors should subclass `TestCase` for their own tests. Construction and deconstruction of the test's environment ('fixture') can be implemented by overriding the 'setUp' and 'tearDown' methods respectively.

If it is necessary to override the `__init__` method, the base class `__init__` method must always be called. It is important that subclasses should not change the signature of their `__init__` method, since instances of the classes are instantiated automatically by parts of the framework in order to be run.

When subclassing `TestCase`, you can set these attributes: \* `failureException`: determines which exception will be raised when

the instance's assertion methods fail; test methods raising this exception will be deemed to have 'failed' rather than 'errored'.

- **longMessage**: determines whether long messages (including repr of objects used in assert methods) will be printed on failure in *addition* to any explicit message passed.

- **maxDiff**: sets the maximum length of a diff in failure messages by assert methods using difflib. It is looked up as an instance attribute so can be configured by individual tests if required.

### **classmethod setUpClass()**

Hook method for setting up class fixture before running tests in the class.

### **classmethod tearDownClass()**

Hook method for deconstructing the class fixture after running all tests in the class.

### **setUp()**

Hook method for setting up the test fixture before exercising it.

### **tearDown()**

Hook method for deconstructing the test fixture after testing it.

### **test\_isppl()**

### **test\_issase1()**

### **test\_issase3()**

### **test\_extractBunchPattern()**

### **test\_pulsePatternInfo()**

`toolbox_scs.test.test_misc.list_suites()`

`toolbox_scs.test.test_misc.suite(*tests)`

`toolbox_scs.test.test_misc.start_tests(*cliargs)`

`toolbox_scs.test.test_misc.parser`

`toolbox_scs.test.test_top_level`

## Module Contents

### Classes

---

*TestToolbox*

A class whose instances are single test cases.

---

### Functions

---

*list\_suites()*

---

*suite(\*tests)*

---

*main(\*cliargs)*

---

---

## Attributes

---

*log\_root*

---

*suites*

---

*parser*

---

`toolbox_scs.test.test_top_level.log_root`

`toolbox_scs.test.test_top_level.suites`

**class** `toolbox_scs.test.test_top_level.TestToolbox`(*methodName='runTest'*)

Bases: `unittest.TestCase`

A class whose instances are single test cases.

By default, the test code itself should be placed in a method named 'runTest'.

If the fixture may be used for many test cases, create as many test methods as are needed. When instantiating such a TestCase subclass, specify in the constructor arguments the name of the test method that the instance is to execute.

Test authors should subclass TestCase for their own tests. Construction and deconstruction of the test's environment ('fixture') can be implemented by overriding the 'setUp' and 'tearDown' methods respectively.

If it is necessary to override the `__init__` method, the base class `__init__` method must always be called. It is important that subclasses should not change the signature of their `__init__` method, since instances of the classes are instantiated automatically by parts of the framework in order to be run.

When subclassing TestCase, you can set these attributes: \* `failureException`: determines which exception will be raised when

the instance's assertion methods fail; test methods raising this exception will be deemed to have 'failed' rather than 'errored'.

- **longMessage**: determines whether long messages (including repr of objects used in assert methods) will be printed on failure in *addition* to any explicit message passed.
- **maxDiff**: sets the maximum length of a diff in failure messages by assert methods using `difflib`. It is looked up as an instance attribute so can be configured by individual tests if required.

**classmethod** `setUpClass()`

Hook method for setting up class fixture before running tests in the class.

**classmethod** `tearDownClass()`

Hook method for deconstructing the class fixture after running all tests in the class.

**setUp()**

Hook method for setting up the test fixture before exercising it.

**tearDown()**

Hook method for deconstructing the test fixture after testing it.

**test\_constant()**

`test_load()`

`test_openrun()`

`test_openrunpath()`

`test_loadbinnedarray()`

`toolbox_scs.test.test_top_level.list_suites()`

`toolbox_scs.test.test_top_level.suite(*tests)`

`toolbox_scs.test.test_top_level.main(*cliargs)`

`toolbox_scs.test.test_top_level.parser`

`toolbox_scs.test.test_utils`

### Module Contents

#### Classes

---

*TestDataAccess*

A class whose instances are single test cases.

---

#### Functions

---

*list\_suites()*

---

*suite(\*tests)*

---

*main(\*cliargs)*

---

#### Attributes

---

*suites*

---

*parser*

---

`toolbox_scs.test.test_utils.suites`

`toolbox_scs.test.test_utils.list_suites()`

**class** `toolbox_scs.test.test_utils.TestDataAccess`(*methodName='runTest'*)

Bases: `unittest.TestCase`

A class whose instances are single test cases.

By default, the test code itself should be placed in a method named 'runTest'.



If the fixture may be used for many test cases, create as many test methods as are needed. When instantiating such a TestCase subclass, specify in the constructor arguments the name of the test method that the instance is to execute.

Test authors should subclass TestCase for their own tests. Construction and deconstruction of the test's environment ('fixture') can be implemented by overriding the 'setUp' and 'tearDown' methods respectively.

If it is necessary to override the `__init__` method, the base class `__init__` method must always be called. It is important that subclasses should not change the signature of their `__init__` method, since instances of the classes are instantiated automatically by parts of the framework in order to be run.

When subclassing TestCase, you can set these attributes: \* `failureException`: determines which exception will be raised when

the instance's assertion methods fail; test methods raising this exception will be deemed to have 'failed' rather than 'errored'.

- **longMessage**: determines whether long messages (including repr of objects used in assert methods) will be printed on failure in *addition* to any explicit message passed.
- **maxDiff**: sets the maximum length of a diff in failure messages by assert methods using `difflib`. It is looked up as an instance attribute so can be configured by individual tests if required.

**classmethod setUpClass()**

Hook method for setting up class fixture before running tests in the class.

**classmethod tearDownClass()**

Hook method for deconstructing the class fixture after running all tests in the class.

**setUp()**

Hook method for setting up the test fixture before exercising it.

**tearDown()**

Hook method for deconstructing the test fixture after testing it.

**test\_rundir1()**

**test\_rundir2()**

**test\_rundir3()**

`toolbox_scs.test.test_utils.suite(*tests)`

`toolbox_scs.test.test_utils.main(*cliargs)`

`toolbox_scs.test.test_utils.parser`

`toolbox_scs.util`

**Submodules**

`toolbox_scs.util.exceptions`

**Module Contents**

**exception** `toolbox_scs.util.exceptions.ToolBoxError`

Bases: `Exception`

Parent Toolbox exception. (to be defined)

**exception** `toolbox_scs.util.exceptions.ToolBoxPathError`(*message=""*, *path=""*)

Bases: `ToolBoxError`

Parent Toolbox exception. (to be defined)

**exception** `toolbox_scs.util.exceptions.ToolBoxTypeError`(*msg=""*, *dtype=""*)

Bases: `ToolBoxError`

Parent Toolbox exception. (to be defined)

**exception** `toolbox_scs.util.exceptions.ToolBoxValueError`(*msg=""*, *val=None*)

Bases: `ToolBoxError`

Parent Toolbox exception. (to be defined)

**exception** `toolbox_scs.util.exceptions.ToolBoxFileError`(*msg=""*, *val=""*)

Bases: `ToolBoxError`

Parent Toolbox exception. (to be defined)

`toolbox_scs.util.pkg`

### Module Contents

#### Functions

---

`get_version()`

---

`toolbox_scs.util.pkg.get_version()`

### Submodules

`toolbox_scs.constants`

#### Module Contents

`toolbox_scs.constants.mnemonics`

**toolbox\_scs.load**

Toolbox for SCS.

Various utilities function to quickly process data measured at the SCS instruments.

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**Module Contents****Functions**

<code>load</code> ([proposalNB, runNB, fields, data, display, ...])	Load a run and extract the data. Output is an xarray with aligned
<code>run_by_path</code> (path)	Return specified run
<code>find_run_path</code> (proposalNB, runNB[, data])	Return the run path given the specified proposal and run numbers.
<code>open_run</code> (proposalNB, runNB[, subset])	Get extra_data.DataCollection in a given proposal.
<code>get_array</code> ([run, mnemonic, stepsize, subset, data, ...])	Loads one data array for the specified mnemonic and rounds its values to
<code>load_run_values</code> (prop_or_run[, runNB, which])	Load the run value for each mnemonic whose source is a CONTORL
<code>concatenateRuns</code> (runs)	Sorts and concatenate a list of runs with identical data variables
<code>check_data_rate</code> (run[, fields])	Calculates the fraction of train ids that contain data in a run.

`toolbox_scs.load.load`(*proposalNB=None, runNB=None, fields=None, data='all', display=False, validate=False, subset=None, rois={}, extract\_digitizers=True, extract\_xgm=True, extract\_bam=True, bunchPattern='sase3', parallelize=True*)

Load a run and extract the data. Output is an xarray with aligned trainIds.

**Parameters**

- **proposalNB** (*str, int*) – proposal number e.g. ‘p002252’ or 2252
- **runNB** (*str, int*) – run number as integer
- **fields** (*str, list of str, list of dict*) – list of mnemonics to load specific data such as “fastccd”, “SCS\_XGM”, or dictionaries defining a custom mnemonic such as {“extra”: {‘source’: ‘SCS\_CDIFFT\_MAG/SUPPLY/CURRENT’, ‘key’: ‘actual\_current.value’, ‘dim’: None}}
- **data** (*str or Sequence of str*) – ‘raw’, ‘proc’ (processed), or any other location relative to the proposal path with data per run to access. May also be ‘all’ (both ‘raw’ and ‘proc’) or a sequence of strings to load data from several locations, with later locations overwriting sources present in earlier ones. The default is ‘raw’.
- **display** (*bool*) – whether to show the run.info or not
- **validate** (*bool*) – whether to run extra-data-validate or not
- **subset** (*slice or extra\_data.by\_index or numpy.s\_*) – a subset of train that can be loaded with `extra_data.by_index[:5]` for the first 5 trains. If None, all trains are retrieved.

- **rois** (*dict*) – a dictionary of mnemonics with a list of rois definition and the desired names, for example: `{'fastccd': {'ref': {'roi': by_index[730:890, 535:720], 'dim': ['ref_x', 'ref_y']},`
- **extract\_digitizers** (*bool*) – If True, extracts the peaks from digitizer variables and aligns the pulse Id according to the fadc\_bp bunch pattern.
- **extract\_xgm** (*bool*) – If True, extracts the values from XGM variables (e.g. 'SCS\_SA3', 'XTD10\_XGM') and aligns the pulse Id with the sase1 / sase3 bunch pattern.
- **extract\_bam** (*bool*) – If True, extracts the values from BAM variables (e.g. 'BAM1932M') and aligns the pulse Id with the sase3 bunch pattern.
- **bunchPattern** (*str*) – bunch pattern used to extract the Fast ADC pulses. A string or a dict as in:

```
{'FFT_PD2': 'sase3', 'ILH_I0': 'scs_ppl'}
```

Ignored if `extract_digitizers=False`.

- **parallelize** (*bool*) – from EXtra-Data: enable or disable opening files in parallel. Particularly useful if creating child processes is not allowed (e.g. in a daemonized multiprocessing.Process).

#### Returns

**run, ds** – `extra_data.DataCollection` of the proposal and run number and an `xarray.Dataset` with aligned `trainIds` and `pulseIds`

#### Return type

`DataCollection`, `xarray.Dataset`

### Example

```
>>> import toolbox_scs as tb
>>> run, data = tb.load(2212, 208, ['SCS_SA3', 'MCP2apd', 'nrj'])
```

`toolbox_scs.load.run_by_path(path)`

Return specified run

Wraps the `extra_data.RunDirectory` routine, to ease its use for the `scs-toolbox` user.

#### Parameters

**path** (*str*) – path to the run directory

#### Returns

**run** – `DataCollection` object containing information about the specified run. Data can be loaded using built-in class methods.

#### Return type

`extra_data.DataCollection`

`toolbox_scs.load.find_run_path(proposalNB, runNB, data='raw')`

Return the run path given the specified proposal and run numbers.

#### Parameters

- **proposalNB** ((*str*, *int*)) – proposal number e.g. ‘p002252’ or 2252
- **runNB** ((*str*, *int*)) – run number as integer
- **data** (*str*) – ‘raw’, ‘proc’ (processed) or ‘all’ (both ‘raw’ and ‘proc’) to access data from either or both of those folders. If ‘all’ is used, sources present in ‘proc’ overwrite those in ‘raw’. The default is ‘raw’.

**Returns**

**path** – The run path.

**Return type**

str

`toolbox_scs.load.open_run(proposalNB, runNB, subset=None, **kwargs)`

Get `extra_data.DataCollection` in a given proposal. Wraps the `extra_data.open_run` routine and adds subset selection, out of convenience for the toolbox user. More information can be found in the `extra_data` documentation.

**Parameters**

- **proposalNB** ((*str*, *int*)) – proposal number e.g. ‘p002252’ or 2252
- **runNB** ((*str*, *int*)) – run number e.g. 17 or ‘r0017’
- **subset** (slice or `extra_data.by_index` or `numpy.s_`) – a subset of train that can be loaded with `extra_data.by_index[:5]` for the first 5 trains. If `None`, all trains are retrieved.
- **\*\*kwargs** –
- ----- –
- **data** (*str*) – default -> ‘raw’
- **include** (*str*) – default -> ‘\*’

**Returns**

**run** – `DataCollection` object containing information about the specified run. Data can be loaded using built-in class methods.

**Return type**

`extra_data.DataCollection`

`toolbox_scs.load.get_array(run=None, mnemonic=None, stepsize=None, subset=None, data='raw', proposalNB=None, runNB=None)`

Loads one data array for the specified mnemonic and rounds its values to integer multiples of stepsize for consistent grouping (except for `stepsize=None`). Returns a 1D array of ones if mnemonic is set to `None`.

**Parameters**

- **run** (`extra_data.DataCollection`) – `DataCollection` containing the data. Used if `proposalNB` and `runNB` are `None`.
- **mnemonic** (*str*) – Identifier of a single item in the mnemonic collection. `None` creates a dummy 1D array of ones with length equal to the number of trains.
- **stepsize** (*float*) – nominal stepsize of the array data - values will be rounded to integer multiples of this value.
- **subset** (slice or `extra_data.by_index` or `numpy.s_`) – a subset of train that can be loaded with `extra_data.by_index[:5]` for the first 5 trains. If `None`, all trains are retrieved.
- **data** (*str* or *Sequence of str*) – ‘raw’, ‘proc’ (processed), or any other location relative to the proposal path with data per run to access. May also be ‘all’ (both ‘raw’ and ‘proc’)

or a sequence of strings to load data from several locations, with later locations overwriting sources present in earlier ones. The default is 'raw'.

- **proposalNB** ((*str*, *int*)) – proposal number e.g. 'p002252' or 2252.
- **runNB** ((*str*, *int*)) – run number e.g. 17 or 'r0017'.

#### Returns

**data** – xarray DataArray containing rounded array values using the trainId as coordinate.

#### Return type

xarray.DataArray

#### Raises

**ToolBoxValueError** – Exception: Toolbox specific exception, indicating a non-valid mnemonic entry

### Example

```
>>> import toolbox_scs as tb
>>> run = tb.open_run(2212, 235)
>>> mnemonic = 'PP800_PhaseShifter'
>>> data_PhaseShifter = tb.get_array(run, mnemonic, 0.5)
```

`toolbox_scs.load.load_run_values(prop_or_run, runNB=None, which='mnemonics')`

Load the run value for each mnemonic whose source is a CONTORL source (see extra-data DataCollection.get\_run\_value() for details)

#### Parameters

- **prop\_or\_run** (*extra\_data DataCollection* or *int*) – The run (DataCollection) to check for mnemonics. Alternatively, the proposal number (int), for which the runNB is also required.
- **runNB** (*int*) – The run number. Only used if the first argument is the proposal number.
- **which** (*str*) – 'mnemonics' or 'all'. If 'mnemonics', only the run values for the ToolBox mnemonics are retrieved. If 'all', a compiled dictionary of all control sources run values is returned.
- **Output** –
- ----- –
- **run\_values** (*a dictionary containing the mnemonic or all run values.*) –

`toolbox_scs.load.concatenateRuns(runs)`

Sorts and concatenate a list of runs with identical data variables along the trainId dimension.

#### Input:

runs: (list) the xarray Datasets to concatenate

#### Output:

a concatenated xarray Dataset

`toolbox_scs.load.check_data_rate(run, fields=None)`

Calculates the fraction of train ids that contain data in a run.

#### Parameters

- **run** (*extra\_data DataCollection*) – the DataCollection associated to the data.

- **fields** (*str, list of str or dict*) – mnemonics to check. If None, all mnemonics in the run are checked. A custom mnemonic can be defined with a dictionary: {'extra': {'source': 'SCS\_CDIFFT\_MAG/SUPPLY/CURRENT', 'key': 'actual\_current.value'}}
- **Output** –
- ----- – ret: dictionary dictionary with mnemonic as keys and fraction of train ids that contain data as values.

### toolbox\_scs.mnemonics\_machinery

Handling ToolBox mnemonics sub-routines

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(contributions preferably comply with pep8 code structure guidelines.)

## Module Contents

### Functions

---

<i>mnemonics_for_run</i> (prop_or_run[, runNB])	Returns the available ToolBox mnemonics for a give extra_data
---	---

---

toolbox\_scs.mnemonics\_machinery.**mnemonics\_for\_run**(*prop\_or\_run, runNB=None*)

Returns the available ToolBox mnemonics for a give extra\_data DataCollection, or a given proposal + run number.

#### Parameters

- **prop\_or\_run** (*extra\_data DataCollection or int*) – The run (DataCollection) to check for mnemonics. Alternatively, the proposal number (int), for which the runNB is also required.
- **runNB** (*int*) – The run number. Only used if the first argument is the proposal number.

#### Returns

**mnemonics** – The dictionary of mnemonics that are available in the run.

#### Return type

dict

### Example

```
>>> import toolbox_scs as tb
>>> tb.mnemonics_for_run(2212, 213)
```

## Package Contents

### Classes

<i>AzimuthalIntegrator</i>	
<i>AzimuthalIntegratorDSSC</i>	
<i>DSSCBinner</i>	
<i>DSSCFormatter</i>	
<i>hRIXS</i>	The hRIXS analysis, especially curvature correction
<i>MaranaX</i>	A spin-off of the hRIXS class: with parallelized centroiding
<i>Viking</i>	The Viking analysis (spectrometer used in combination with Andor Newton)
<i>parameters</i>	Parameters contains all input parameters for the BOZ corrections.

### Functions

<i>get_bam</i> (run[, mnemonics, merge_with, bunchPattern, ...])	Load beam arrival monitor (BAM) data and align their pulse ID
<i>get_bam_params</i> (run[, mnemo_or_source])	Extract the run values of bamStatus[1-3] and bamError.
<i>check_peak_params</i> (run, mnemonic[, raw_trace, ntrains, ...])	Checks and plots the peak parameters (pulse window and baseline window)
<i>get_digitizer_peaks</i> (run, mnemonic[, merge_with, ...])	Automatically computes digitizer peaks. A source can be loaded on the
<i>get_laser_peaks</i> (run[, mnemonic, merge_with, ...])	Extracts laser photodiode signal (peak intensity) from Fast ADC
<i>get_peaks</i> (run, data, mnemonic[, useRaw, autoFind, ...])	Extract peaks from one source (channel) of a digitizer.
<i>get_tim_peaks</i> (run[, mnemonic, merge_with, ...])	Automatically computes TIM peaks. Sources can be loaded on the
<i>digitizer_signal_description</i> (run[, digitizer])	Check for the existence of signal description and return all corresponding
<i>get_dig_avg_trace</i> (run, mnemonic[, ntrains])	Compute the average over ntrains evenly spaced across all trains
<i>get_data_formatted</i> ([filenames, data_list])	Combines the given data into one dataset. For any of extra_data's data
<i>load_xarray</i> (fname[, group, form])	Load stored xarray Dataset.
<i>save_attributes_h5</i> (fname[, data])	Adding attributes to a hdf5 file. This function is intended to be used to
<i>save_xarray</i> (fname, data[, group, mode])	Store xarray Dataset in the specified location
<i>create_dssc_bins</i> (name, coordinates, bins)	Creates a single entry for the dssc binner dictionary. The produced xarray
<i>get_xgm_formatted</i> (run_obj, xgm_name, dssc_frame_coords)	Load the xgm data and define coordinates along the pulse dimension.

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Table 2 – continued from previous page

<i>load_dssc_info</i> (proposal, run_nr)	Loads the first data file for DSSC module 0 (this is hard-coded)
<i>load_mask</i> (fname, dssc_mask)	Load a DSSC mask file.
<i>quickmask_DSSC_ASIC</i> (poslist)	Returns a mask for the given DSSC geometry with ASICs given in poslist
<i>process_dssc_data</i> (proposal, run_nr, module, chunksize, ...)	Collects and reduces DSSC data for a single module.
<i>extract_GH2</i> (ds, run[, firstFrame, bunchPattern, gh2_dim])	Select and align the frames of the Gotthard-II that have been exposed
<i>get_pes_params</i> (run[, channel])	Extract PES parameters for a given extra_data DataCollection.
<i>get_pes_tof</i> (proposal, runNB, mnemonic[, start, ...])	Extracts time-of-flight spectra from raw digitizer traces. The spectra
<i>save_pes_avg_traces</i> (proposal, runNB[, channels, subdir])	Save average traces of PES into an h5 file.
<i>load_pes_avg_traces</i> (proposal, runNB[, channels, subdir])	Load existing PES average traces.
<i>calibrate_xgm</i> (run, data[, xgm, plot])	Calculates the calibration factor F between the photon flux (slow signal)
<i>get_xgm</i> (run[, mnemonics, merge_with, indices])	Load and/or computes XGM data. Sources can be loaded on the
<i>concatenateRuns</i> (runs)	Sorts and concatenate a list of runs with identical data variables
<i>find_run_path</i> (proposalNB, runNB[, data])	Return the run path given the specified proposal and run numbers.
<i>get_array</i> ([run, mnemonic, stepsize, subset, data, ...])	Loads one data array for the specified mnemonic and rounds its values to
<i>load</i>	Toolbox for SCS.
<i>open_run</i> (proposalNB, runNB[, subset])	Get extra_data.DataCollection in a given proposal.
<i>run_by_path</i> (path)	Return specified run
<i>load_run_values</i> (prop_or_run[, runNB, which])	Load the run value for each mnemonic whose source is a CONTORL
<i>check_data_rate</i> (run[, fields])	Calculates the fraction of train ids that contain data in a run.
<i>extractBunchPattern</i> ([bp_table, key, runDir])	generate the bunch pattern and number of pulses of a source directly from the
<i>get_sase_pId</i> (run[, loc, run_mnemonics, bpt, merge_with])	Returns the pulse Ids of the specified <i>loc</i> during a run.
<i>npulses_has_changed</i> (run[, loc, run_mnemonics])	Checks if the number of pulses has changed during the run for
<i>pulsePatternInfo</i> (data[, plot])	display general information on the pulse patterns operated by SASE1 and SASE3.
<i>repRate</i> ([data, runNB, proposalNB, key])	Calculates the pulse repetition rate (in kHz) in sase
<i>is_sase_3</i> (bpt)	Check for prescence of a SASE3 pulse.
<i>is_sase_1</i> (bpt)	Check for prescence of a SASE1 pulse.
<i>is_pp1</i> (bpt)	Check for prescence of pp-laser pulse.
<i>is_pulse_at</i> (bpt, loc)	Check for prescence of a pulse at the location provided.
<i>degToRelPower</i> (x[, theta0])	converts a half-wave plate position in degrees into relative power
<i>positionToDelay</i> (pos[, origin, invert, reflections])	converts a motor position in mm into optical delay in picosecond

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Table 2 – continued from previous page

<i>delayToPosition</i> (delay[, origin, invert, reflections])	converts an optical delay in picosecond into a motor position in mm
<i>fluenceCalibration</i> (hwp, power_mW, npulses, w0x[, w0y, ...])	Given a measurement of relative powers or half wave plate angles
<i>align_ol_to_fel_pId</i> (ds[, ol_dim, fel_dim, offset, ...])	Aligns the optical laser (OL) pulse Ids to the FEL pulse Ids.
<i>get_undulator_config</i> (run[, park_pos, plot])	Extract the undulator cells configuration from a given run.
<i>mnemonics_for_run</i> (prop_or_run[, runNB])	Returns the available ToolBox mnemonics for a give extra_data
<i>xas</i> (nrun[, bins, Iokey, Itkey, nrjkey, Iooffset, ...])	Compute the XAS spectra from a xarray nrun.
<i>xasxmc</i> (dataP, dataN)	Compute XAS and XMCD from data with both magnetic field direction
<i>get_roi_pixel_pos</i> (roi, params)	Compute fake or real pixel position of an roi from roi center.
<i>bad_pixel_map</i> (params)	Compute the bad pixels map.
<i>inspect_dark</i> (arr[, mean_th, std_th])	Inspect dark run data and plot diagnostic.
<i>histogram_module</i> (arr[, mask])	Compute a histogram of the 9 bits raw pixel values over a module.
<i>inspect_histogram</i> (arr[, arr_dark, mask, extra_lines])	Compute and plot a histogram of the 9 bits raw pixel values.
<i>find_rois</i> (data_mean, threshold[, extended])	Find rois from 3 beams configuration.
<i>find_rois_from_params</i> (params)	Find rois from 3 beams configuration.
<i>inspect_rois</i> (data_mean, rois[, threshold, allrois])	Find rois from 3 beams configuration from mean module image.
<i>compute_flat_field_correction</i> (rois, params[, plot])	
<i>inspect_flat_field_domain</i> (avg, rois, prod_th, ratio_th)	Extract beams roi from average image and compute the ratio.
<i>inspect_plane_fitting</i> (avg, rois[, domain, vmin, vmax])	
<i>plane_fitting_domain</i> (avg, rois, prod_th, ratio_th)	Extract beams roi, compute their ratio and the domain.
<i>plane_fitting</i> (params)	Fit the plane flat-field normalization.
<i>ff_refine_crit</i> (p, alpha, params, arr_dark, arr, tid, ...)	Criteria for the ff_refine_fit.
<i>ff_refine_fit</i> (params[, crit])	Refine the flat-field fit by minimizing data spread.
<i>nl_domain</i> (N, low, high)	Create the input domain where the non-linear correction defined.
<i>nl_lut</i> (domain, dy)	Compute the non-linear correction.
<i>nl_crit</i> (p, domain, alpha, arr_dark, arr, tid, rois, ...)	Criteria for the non linear correction.
<i>nl_crit_sk</i> (p, domain, alpha, arr_dark, arr, tid, rois, ...)	Non linear correction criteria, combining 'n' and 'p' as reference.
<i>nl_fit</i> (params, domain[, ff, crit])	Fit non linearities correction function.
<i>inspect_nl_fit</i> (res_fit)	Plot the progress of the fit.
<i>snr</i> (sig, ref[, methods, verbose])	Compute mean, std and SNR from transmitted and I0 signals.
<i>inspect_Fnl</i> (Fnl)	Plot the correction function Fnl.
<i>inspect_correction</i> (params[, gain])	Comparison plot of the different corrections.
<i>inspect_correction_sk</i> (params, ff[, gain])	Comparison plot of the different corrections, combining 'n' and 'p'.

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Table 2 – continued from previous page

<code>load_dssc_module</code> (proposalNB, runNB[, moduleNB, ...])	Load single module dssc data as dask array.
<code>average_module</code> (arr[, dark, ret, mask, sat_roi, ...])	Compute the average or std over a module.
<code>process_module</code> (arr, tid, dark, rois[, mask, ...])	Process one module and extract roi intensity.
<code>process</code> (Fmodel, arr_dark, arr, tid, rois, mask, flat_field)	Process dark and run data with corrections.
<code>inspect_saturation</code> (data, gain[, Nbins])	Plot roi integrated histogram of the data with saturation
<code>reflectivity</code> (data[, Iokey, Irkey, delaykey, binWidth, ...])	Computes the reflectivity $R = 100 * (I_r / I_o[\text{pumped}] / I_r / I_o[\text{unpumped}] - 1)$
<code>knife_edge</code> (ds[, axisKey, signalKey, axisRange, p0, ...])	Calculates the beam radius at $1/e^2$ from a knife-edge scan by

## Attributes

---

`mnemonics`

---

`__all__`

---

`__all__`

---

`__all__`

---

`__all__`

---

`toolbox_scs.mnemonics`

`toolbox_scs.__all__`

**class** `toolbox_scs.AzimuthalIntegrator`(*imageshape, center, polar\_range, aspect=204 / 236, \*\*kwargs*)

Bases: object

`_calc_dist_array`(*shape, center, aspect*)

Calculate pixel coordinates for the given shape.

`_calc_indices`(*\*\*kwargs*)

Calculates the list of indices for the flattened image array.

`_calc_polar_mask`(*polar\_range*)

`calc_q`(*distance, wavelength*)

Calculate momentum transfer coordinate.

### Parameters

- **distance** (*float*) – Sample - detector distance in meter
- **wavelength** (*float*) – wavelength of scattered light in meter

### Returns

**deltaq** – Momentum transfer coordinate in 1/m

### Return type

`np.ndarray`

`__call__(image)`

`class toolbox_scs.AzimuthalIntegratorDSSC(geom, polar_range, dxdy=(0, 0), **kwargs)`

Bases: *AzimuthalIntegrator*

`_calc_dist_array(geom, dxdy)`

Calculate pixel coordinates for the given shape.

`toolbox_scs.get_bam(run, mnemonics=None, merge_with=None, bunchPattern='sase3', pulseIds=None)`

Load beam arrival monitor (BAM) data and align their pulse ID according to the bunch pattern. Sources can be loaded on the fly via the mnemonics argument, or processed from an existing data set (*merge\_with*).

#### Parameters

- **run** (*extra\_data.DataCollection*) – DataCollection containing the bam data.
- **mnemonics** (*str or list of str*) – mnemonics for BAM, e.g. “BAM1932M” or [“BAM414”, “BAM1932M”]. the arrays are either taken from *merge\_with* or loaded from the DataCollection *run*.
- **merge\_with** (*xarray Dataset*) – If provided, the resulting Dataset will be merged with this one. If *merge\_with* contains variables in *mnemonics*, they will be selected, aligned and merged.
- **bunchPattern** (*str*) – ‘sase1’ or ‘sase3’ or ‘scs\_ppl’, bunch pattern used to extract peaks. The pulse ID dimension will be named ‘sa1\_pId’, ‘sa3\_pId’ or ‘ol\_pId’, respectively.
- **pulseIds** (*list, 1D array*) – Pulse Ids. If None, they are automatically loaded.

#### Returns

merged with Dataset *merge\_with* if provided.

#### Return type

xarray Dataset with pulse-resolved BAM variables aligned,

### Example

```
>>> import toolbox_scs as tb
>>> run = tb.open_run(2711, 303)
>>> bam = tb.get_bam(run, 'BAM1932S')
```

`toolbox_scs.get_bam_params(run, mnemo_or_source='BAM1932S')`

Extract the run values of *bamStatus[1-3]* and *bamError*.

#### Parameters

- **run** (*extra\_data.DataCollection*) – DataCollection containing the bam data.
- **mnemo\_or\_source** (*str*) – mnemonic of the BAM, e.g. ‘BAM414’, or source name, e.g. ‘SCS\_ILH\_LAS/DOOCS/BAM\_414\_B2’.

#### Returns

**params** – dictionary containing the extracted parameters.

#### Return type

dict

---

**Note:** The extracted parameters are run values, they do not reflect any possible change during the run.

---

```
toolbox_scs.check_peak_params(run, mnemonic, raw_trace=None, ntrains=200, params=None, plot=True,
                             show_all=False, bunchPattern='sase3')
```

Checks and plots the peak parameters (pulse window and baseline window of a raw digitizer trace) used to compute the peak integration. These parameters are either set by the digitizer peak-integration settings, or are determined by a peak finding algorithm (used in `get_tim_peaks` or `get_fast_adc_peaks`) when the inputs are raw traces. The parameters can also be provided manually for visual inspection. The plot either shows the first and last pulse of the trace or the entire trace.

#### Parameters

- **run** (*extra\_data.DataCollection*) – DataCollection containing the digitizer data.
- **mnemonic** (*str*) – ToolBox mnemonic of the digitizer data, e.g. ‘MCP2apd’.
- **raw\_trace** (*optional, 1D numpy array or xarray DataArray*) – Raw trace to display. If None, the average raw trace over ntrains of the corresponding channel is loaded (this can be time-consuming).
- **ntrains** (*optional, int*) – Only used if raw\_trace is None. Number of trains used to calculate the average raw trace of the corresponding channel.
- **plot** (*bool*) – If True, displays the raw trace and peak integration regions.
- **show\_all** (*bool*) – If True, displays the entire raw trace and all peak integration regions (this can be time-consuming). If False, shows the first and last pulse according to the bunchPattern.
- **bunchPattern** (*optional, str*) – Only used if plot is True. Checks the bunch pattern against the digitizer peak parameters and shows potential mismatch.

#### Return type

dictionary of peak integration parameters

```
toolbox_scs.get_digitizer_peaks(run, mnemonic, merge_with=None, bunchPattern='sase3',
                               integParams=None, keepAllSase=False)
```

Automatically computes digitizer peaks. A source can be loaded on the fly via the mnemonic argument, or processed from an existing data set (`merge_with`). The bunch pattern table is used to assign the pulse id coordinates.

#### Parameters

- **run** (*extra\_data.DataCollection*) – DataCollection containing the digitizer data.
- **mnemonic** (*str*) – mnemonic for FastADC or ADQ412, e.g. “I0\_ILHraw” or “MCP3apd”. The data is either loaded from the DataCollection or taken from `merge_with`.
- **merge\_with** (*xarray Dataset*) – If provided, the resulting Dataset will be merged with this one.
- **bunchPattern** (*str or dict*) – ‘sase1’ or ‘sase3’ or ‘scs\_ppl’, ‘None’: bunch pattern
- **integParams** (*dict*) – dictionary for raw trace integration, e.g. {‘pulseStart’:100, ‘pulsestop’:200, ‘baseStart’:50, ‘baseStop’:99, ‘period’:24, ‘npulses’:500}. If None, integration parameters are computed automatically.
- **keepAllSase** (*bool*) – Only relevant in case of sase-dedicated trains. If True, all trains are kept, else only those of the bunchPattern are kept.

#### Returns

- *xarray Dataset with digitizer peak variables. Raw variables are*
- *substituted by the peak calculated values (e.g. “FastADC2raw” becomes*
- *”FastADC2peaks”).*

`toolbox_scs.get_laser_peaks`(*run*, *mnemonic=None*, *merge\_with=None*, *bunchPattern='scs\_ppl'*, *integParams=None*)

Extracts laser photodiode signal (peak intensity) from Fast ADC digitizer. Sources can be loaded on the fly via the mnemonics argument, and/or processed from an existing data set (*merge\_with*). The PP laser bunch pattern is used to assign the pulse idcoordinates.

#### Parameters

- **run** (*extra\_data.DataCollection*) – DataCollection containing the digitizer data.
- **mnemonic** (*str*) – mnemonic for FastADC corresponding to laser signal, e.g. “FastADC2peaks” or ‘IO\_ILHraw’.
- **merge\_with** (*xarray Dataset*) – If provided, the resulting Dataset will be merged with this one. The FastADC variables of *merge\_with* (if any) will also be computed and merged.
- **bunchPattern** (*str*) – ‘sase1’ or ‘sase3’ or ‘scs\_ppl’, bunch pattern used to extract peaks.
- **integParams** (*dict*) – dictionary for raw trace integration, e.g. {‘pulseStart’:100, ‘pulsestop’:200, ‘baseStart’:50, ‘baseStop’:99, ‘period’:24, ‘npulses’:500}. If None, integration parameters are computed automatically.

#### Returns

- *xarray Dataset* with all Fast ADC variables substituted by
- the peak caclulated values (e.g. “FastADC2raw” becomes
- ”FastADC2peaks”).

`toolbox_scs.get_peaks`(*run*, *data*, *mnemonic*, *useRaw=True*, *autoFind=True*, *integParams=None*, *bunchPattern='sase3'*, *bpt=None*, *extra\_dim=None*, *indices=None*)

Extract peaks from one source (channel) of a digitizer.

#### Parameters

- **run** (*extra\_data.DataCollection*) – DataCollection containing the digitizer data
- **data** (*xarray DataArray* or *str*) – array containing the raw traces or peak-integrated values from the digitizer. If *str*, must be one of the ToolBox mnemonics. If None, the data is loaded via the source and key arguments.
- **mnemonic** (*str* or *dict*) – ToolBox mnemonic or dict with source and key as in {‘source’: ‘SCS\_UTC1\_ADQ/ADC/1:network’, ‘key’: ‘digitizers.channel\_1\_A.raw.samples’}
- **useRaw** (*bool*) – If True, extract peaks from raw traces. If False, uses the APD (or peaks) data from the digitizer.
- **autoFind** (*bool*) – If True, finds integration parameters by inspecting the average raw trace. Only valid if *useRaw* is True.
- **integParams** (*dict*) – dictionary containing the integration parameters for raw trace integration: ‘pulseStart’, ‘pulseStop’, ‘baseStart’, ‘baseStop’, ‘period’, ‘npulses’. Not used if *autoFind* is True. All keys are required when *bunchPattern* is missing.
- **bunchPattern** (*str*) – match the peaks to the bunch pattern: ‘sase1’, ‘sase3’, ‘scs\_ppl’. This will dictate the name of the pulse ID coordinates: ‘sa1\_pId’, ‘sa3\_pId’ or ‘scs\_ppl’.
- **bpt** (*xarray DataArray*) – bunch pattern table
- **extra\_dim** (*str*) – Name given to the dimension along the peaks. If None, the name is given according to the *bunchPattern*.

- **indices** (*array, slice*) – indices from the peak-integrated data to retrieve. Only required when bunch pattern is missing and useRaw is False.

**Return type**

xarray.DataArray containing digitizer peaks with pulse coordinates

```
toolbox_scs.get_tim_peaks(run, mnemonic=None, merge_with=None, bunchPattern='sase3',
                          integParams=None, keepAllSase=False)
```

Automatically computes TIM peaks. Sources can be loaded on the fly via the mnemonics argument, or processed from an existing data set (*merge\_with*). The bunch pattern table is used to assign the pulse id coordinates.

**Parameters**

- **run** (*extra\_data.DataCollection*) – DataCollection containing the digitizer data.
- **mnemonic** (*str*) – mnemonics for TIM, e.g. “MCP2apd”.
- **merge\_with** (*xarray Dataset*) – If provided, the resulting Dataset will be merged with this one. The TIM variables of *merge\_with* (if any) will also be computed and merged.
- **bunchPattern** (*str*) – ‘sase1’ or ‘sase3’ or ‘scs\_ppl’, bunch pattern used to extract peaks. The pulse ID dimension will be named ‘sa1\_pId’, ‘sa3\_pId’ or ‘ol\_pId’, respectively.
- **integParams** (*dict*) – dictionary for raw trace integration, e.g. {‘pulseStart’:100, ‘pulsestop’:200, ‘baseStart’:50, ‘baseStop’:99, ‘period’:24, ‘npulses’:500}. If None, integration parameters are computed automatically.
- **keepAllSase** (*bool*) – Only relevant in case of sase-dedicated trains. If True, all trains are kept, else only those of the bunchPattern are kept.

**Returns**

- *xarray Dataset with TIM variables substituted by*
- *the peak caclulated values (e.g. “MCP2raw” becomes*
- *”MCP2peaks”), merged with Dataset \*merge\_with if provided.\**

```
toolbox_scs.digitizer_signal_description(run, digitizer=None)
```

Check for the existence of signal description and return all corresponding channels in a dictionary.

**Parameters**

- **run** (*extra\_data.DataCollection*) – DataCollection containing the digitizer data.
- **digitizer** (*str or list of str (default=None)*) – Name of the digitizer: one in [‘FastADC’, ‘FastADC2’, ‘ADQ412’, ‘ADQ412\_2’] If None, all digitizers are used

**Returns**

**signal\_description** – the digitizer channels.

**Return type**

dictionary containing the signal description of

### Example

```
import toolbox_scs as tb
run = tb.open_run(3481, 100)
signals = tb.digitizer_signal_description(run)
signals_fadc2 = tb.digitizer_signal_description(run, 'FastADC2')
```

```
toolbox_scs.get_dig_avg_trace(run, mnemonic, ntrains=None)
```

Compute the average over ntrains evenly spaced accross all trains of a digitizer trace.

#### Parameters

- **run** (*extra\_data.DataCollection*) – DataCollection containing the digitizer data.
- **mnemonic** (*str*) – ToolBox mnemonic of the digitizer data, e.g. 'MCP2apd'.
- **ntrains** (*int*) – Number of trains used to calculate the average raw trace. If None, all trains are used.

#### Returns

**trace** – The average digitizer trace

#### Return type

DataArray

```
class toolbox_scs.DSSCBinner(proposal_nr, run_nr, bidders={}, xgm_name='SCS_SA3',
                             tim_names=['MCP1apd', 'MCP2apd', 'MCP3apd'], dssc_coords_stride=2)
```

```
__del__()
```

```
add_binner(name, binner)
```

Add additional binner to internal dictionary

#### Parameters

- **name** (*str*) – name of binner to be created
- **binner** (*xarray.DataArray*) – An array that represents a map how the respective coordinate should be binned.

#### Raises

**ToolBoxValueError** – Exception: Raises exception in case the name does not correspond to a valid binner name. To be generalized.

```
load_xgm()
```

load xgm data and construct coordinate array according to corresponding dssc frame number.

```
load_tim()
```

load tim data and construct coordinate array according to corresponding dssc frame number.

```
create_pulsemask(use_data='xgm', threshold=(0, np.inf))
```

creates a mask for dssc frames according to measured xgm intensity. Once such a mask has been constructed, it will be used in the data reduction process to drop out-of-bounds pulses.

```
get_info()
```

Returns the expected shape of the binned dataset, in case bidders have been defined.

```
_bin_metadata(data)
```

```
get_xgm_binned()
```

Bin the xgm data according to the bidders of the dssc data. The result can eventually be merged into the final dataset by the DSSCFormatter.



**Returns**

**xgm\_data** – xarray dataset containing the binned xgm data

**Return type**

xarray.DataSet

**get\_tim\_binned()**

Bin the tim data according to the bidders of the dssc data. The result can eventually be merged into the final dataset by the DSSCFormatter.

**Returns**

**tim\_data** – xarray dataset containing the binned tim data

**Return type**

xarray.DataSet

**process\_data**(*modules=[]*, *filepath='./*, *chunksize=512*, *backend='loky'*, *n\_jobs=None*, *dark\_image=None*, *xgm\_normalization=False*, *normevery=1*)

Load and bin dssc data according to self.bins. No data is returned by this method. The condensed data is written to file by the worker processes directly.

**Parameters**

- **modules** (*list of ints*) – a list containing the module numbers that should be processed. If empty, all modules are processed.
- **filepath** (*str*) – the path where the files containing the reduced data should be stored.
- **chunksize** (*int*) – The number of trains that should be read in one iterative step.
- **backend** (*str*) – joblib multiprocessing backend to be used. At the moment it can be any of joblibs standard backends: ‘loky’ (default), ‘multiprocessing’, ‘threading’. Anything else than the default is experimental and not appropriately implemented in the dbdet member function ‘bin\_data’.
- **n\_jobs** (*int*) – inversely proportional of the number of cpu’s available for one job. Tasks within one job can grab a maximum of  $n\_CPU\_tot/n\_jobs$  of cpu’s. Note that when using the default backend there is no need to adjust this parameter with the current implementation.
- **dark\_image** (*xarray.DataArray*) – DataArray with dimensions compatible with the loaded dssc data. If given, it will be subtracted from the dssc data before the binning. The dark image needs to be of dimension module, trainId, pulse, x and y.
- **xgm\_normalization** (*boolean*) – if true, the dssc data is normalized by the xgm data before the binning.
- **normevery** (*int*) – integer indicating which out of normevery frame will be normalized.

**class** toolbox\_scs.DSSCFormatter(*filepath*)

**combine\_files**(*filenames=[]*)

Read the files given in filenames, and store the data in the class variable ‘data’. If no filenames are given, it tries to read the files stored in the class-internal variable ‘\_filenames’.

**Parameters**

**filenames** (*list*) – list of strings containing the names of the files to be combined.

**add\_dataArray**(*groups=[]*)

Reads additional xarray-data from the first file given in the list of filenames. This assumes that all the files in the folder contain the same additional data. To be generalized.

**Parameters**

**groups** (*list*) – list of strings with the names of the groups in the h5 file, containing additional xarray data.

**add\_attributes**(*attributes={}*)

Add additional information, such as run-type, as attributes to the formatted .h5 file.

**Parameters**

**attributes** (*dictionary*) – a dictionary, containing information or data of any kind, that will be added to the formatted .h5 file as attributes.

**save\_formatted\_data**(*filename*)

Create a .h5 file containing the main dataset in the group called 'data'. Additional groups will be created for the content of the variable 'data\_array'. Metadata about the file is added in the form of attributes.

**Parameters**

**filename** (*str*) – the name of the file to be created

`toolbox_scs.get_data_formatted`(*filenames=[], data\_list=[]*)

Combines the given data into one dataset. For any of extra\_data's data types, an xarray.Dataset is returned. The data is sorted along the 'module' dimension. The array dimension have the order 'trainId', 'pulse', 'module', 'x', 'y'. This order is required by the extra\_geometry package.

**Parameters**

- **filenames** (*list of str*) – files to be combined as a list of names. Calls '\_data\_from\_list' to actually load the data.
- **data\_list** (*list*) – list containing the already loaded data

**Returns**

**data** – A xarray.Dataset containing the combined data.

**Return type**

xarray.Dataset

`toolbox_scs.load_xarray`(*fname, group='data', form='dataset'*)

Load stored xarray Dataset. Comment: This function exists because of a problem with the standard netcdf engine that is malfunctioning due to related software installed in the exfel-python environment. May be dropped at some point.

**Parameters**

- **fname** (*str*) – filename as string
- **group** (*str*) – the name of the xarray dataset (group in h5 file).
- **form** (*str*) – specify whether the data to be loaded is a 'dataset' or a 'array'.

`toolbox_scs.save_attributes_h5`(*fname, data={}*)

Adding attributes to a hdf5 file. This function is intended to be used to attach metadata to a processed run.

**Parameters**

- **fname** (*str*) – filename as string
- **data** (*dictionary*) – the data that should be added to the file in form of a dictionary.

`toolbox_scs.save_xarray`(*fname, data, group='data', mode='a'*)

Store xarray Dataset in the specified location

**Parameters**

- **data** (*xarray.DataSet*) – The data to be stored

- **fname** (*str*, *int*) – filename
- **overwrite** (*bool*) – overwrite existing data

**Raises**

***ToolBoxFileError*** – Exception: File existed, but overwrite was set to False.

`toolbox_scs.create_dssc_bins(name, coordinates, bins)`

Creates a single entry for the dssc binner dictionary. The produced xarray data-array will later be used to perform grouping operations according to the given bins.

**Parameters**

- **name** (*str*) – name of the coordinate to be binned.
- **coordinates** (*numpy.ndarray*) – the original coordinate values (1D)
- **bins** (*numpy.ndarray*) – the bins according to which the corresponding dimension should be grouped.

**Returns**

**da** – A pre-formatted `xarray.DataArray` relating the specified dimension with its bins.

**Return type**

`xarray.DataArray`

**Examples**

```
>>> import toolbox_scs as tb
>>> run = tb.open_run(2212, 235, include='*DA*')
```

1.) binner along ‘pulse’ dimension. Group data into two bins. >>> `bins_pulse = [‘pumped’, ‘unpumped’] * 10`  
>>> `binner_pulse = tb.create_dssc_bins(“pulse”,`  
`np.linspace(0,19,20, dtype=int), bins_pulse)`

2.) binner along ‘train’ dimension. Group data into bins corresponding to the positions of a delay stage for instance.

```
>>> bins_trainId = tb.get_array(run, 'PP800_PhaseShifter', 0.04)
>>> binner_train = tb.create_dssc_bins("trainId",
                                     run.trainIds,
                                     bins_trainId.values)
```

`toolbox_scs.get_xgm_formatted(run_obj, xgm_name, dssc_frame_coords)`

Load the xgm data and define coordinates along the pulse dimension.

**Parameters**

- **run\_obj** (*extra\_data.DataCollection*) – `DataCollection` object providing access to the xgm data to be loaded
- **xgm\_name** (*str*) – valid mnemonic of a xgm source
- **dssc\_frame\_coords** (*int*, *list*) – defines which dssc frames should be normalized using data from the xgm.

**Returns**

**xgm** – xgm data with coordinate ‘pulse’.

**Return type**

xarray.DataArray

`toolbox_scs.load_dssc_info(proposal, run_nr)`

Loads the first data file for DSSC module 0 (this is hardcoded) and returns the detector\_info dictionary

**Parameters**

- **proposal** (*str*, *int*) – number of proposal
- **run\_nr** (*str*, *int*) – number of run

**Returns****info** – {'dims': tuple, 'frames\_per\_train': int, 'total\_frames': int}**Return type**

dictionary

`toolbox_scs.load_mask(fname, dssc_mask)`

Load a DSSC mask file.

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**Parameters****fname** (*str*) – string of the filename of the mask file**Return type**

dssc\_mask

`toolbox_scs.quickmask_DSSC_ASIC(poslist)`

Returns a mask for the given DSSC geometry with ASICs given in poslist blanked. poslist is a list of (module, row, column) tuples. Each module consists of 2 rows and 8 columns of individual ASICs.

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`toolbox_scs.process_dssc_data(proposal, run_nr, module, chunksize, info, dssc_bidders, path='./',  
pulsemask=None, dark_image=None, xgm_mnemonic='SCS_SA3',  
xgm_normalization=False, normevery=1)`

Collects and reduces DSSC data for a single module.

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**Parameters**

- **proposal** (*int*) – proposal number
- **run\_nr** (*int*) – run number
- **module** (*int*) – DSSC module to process
- **chunksize** (*int*) – number of trains to load simultaneously
- **info** (*dictionary*) – dictionary containing keys 'dims', 'frames\_per\_train', 'total\_frames', 'trainIds', 'number\_of\_trains'.
- **dssc\_bidders** (*dictionary*) – a dictionary containing binner objects created by the Toolbox member function "create\_binner()"
- **path** (*str*) – location in which the .h5 files, containing the binned data, should be stored.
- **pulsemask** (*numpy.ndarray*) – array of booleans to be used to mask dssc data according to xgm data.

- **dark\_image** (*xarray.DataArray*) – an xarray dataarray with matching coordinates with the loaded data. If dark\_image is not None it will be subtracted from each individual dssc frame.
- **xgm\_normalization** (*bool*) – true if the data should be divided by the corresponding xgm value.
- **xgm\_mnemonic** (*str*) – Mnemonic of the xgm data to be used for normalization.
- **normevery** (*int*) – One out of normevery dssc frames will be normalized.

**Returns**

**module\_data** – xarray datastructure containing data binned according to bins.

**Return type**

*xarray.Dataset*

`toolbox_scs.extract_GH2(ds, run, firstFrame=0, bunchPattern='scs_pp1', gh2_dim='gh2_pId')`

Select and align the frames of the Gotthard-II that have been exposed to light.

**Parameters**

- **ds** (*xarray.Dataset*) – The dataset containing GH2 data
- **run** (*extra\_data.DataCollection*) – The run containing the bunch pattern source
- **firstFrame** (*int*) – The GH2 frame number corresponding to the first pulse of the train.
- **bunchPattern** (*str in ['scs\_pp1', 'sase3']*) – the bunch pattern used to align data. For 'scs\_pp1', the gh2\_pId dimension in renamed 'ol\_pId', and for 'sase3' gh2\_pId is renamed 'sa3\_pId'.
- **gh2\_dim** (*str*) – The name of the dimension that corresponds to the Gotthard-II frames.

**Returns**

**nds** – The aligned and reduced dataset with only-data-containing GH2 variables.

**Return type**

*xarray Dataset*

`class toolbox_scs.hRIXS(proposalNB, detector='MaranaX')`

The hRIXS analysis, especially curvature correction

The objects of this class contain the meta-information about the settings of the spectrometer, not the actual data, except possibly a dark image for background subtraction.

The actual data is loaded into `xarray`s`, and stays there.

**PROPOSAL**

the number of the proposal

**Type**

*int*

**DETECTOR**

the detector to be used. Can be ['hRIXS\_det', 'MaranaX'] defaults to 'hRIXS\_det' for backward-compatibility.

**Type**

*str*

**X\_RANGE**

the slice to take in the dispersive direction, in pixels. Defaults to the entire width.

**Type**  
slice

### **Y\_RANGE**

the slice to take in the energy direction

**Type**  
slice

### **THRESHOLD**

pixel counts above which a hit candidate is assumed, for centroiding. use None if you want to give it in standard deviations instead.

**Type**  
float

### **STD\_THRESHOLD**

same as THRESHOLD, in standard deviations.

### **DBL\_THRESHOLD**

threshold controlling whether a detected hit is considered to be a double hit.

### **BINS**

the number of bins used in centroiding

**Type**  
int

### **CURVE\_A, CURVE\_B**

the coefficients of the parabola for the curvature correction

**Type**  
float

### **USE\_DARK**

whether to do dark subtraction. Is initially *False*, magically switches to *True* if a dark has been loaded, but may be reset.

**Type**  
bool

### **ENERGY\_INTERCEPT, ENERGY\_SLOPE**

The calibration from pixel to energy

### **FIELDS**

the fields to be loaded from the data. Add additional fields if so desired.

## **Example**

```
proposal = 3145 h = hRIXS(proposal) h.Y_RANGE = slice(700, 900) h.CURVE_B = -3.695346575286939e-07
h.CURVE_A = 0.024084479232443695 h.ENERGY_SLOPE = 0.018387 h.ENERGY_INTERCEPT = 498.27
h.STD_THRESHOLD = 3.5
```

### **DETECTOR\_FIELDS**

#### **aggregators**

```
set_params(**params)
```

**get\_params**(\*params)

**from\_run**(runNB, proposal=None, extra\_fields=(), drop\_first=False, subset=None)

load a run

Load the run *runNB*. A thin wrapper around *toolbox.load*. :param drop\_first: if True, the first image in the run is removed from the dataset. :type drop\_first: bool

### Example

```
data = h.from_run(145) # load run 145
```

```
data1 = h.from_run(145) # load run 145 data2 = h.from_run(155) # load run 155
data = xarray.concat([data1, data2], 'trainId') # combine both
```

**load\_dark**(runNB, proposal=None)

load a dark run

Load the dark run *runNB* from *proposal*. The latter defaults to the current proposal. The dark is stored in this *hRIXS* object, and subsequent analyses use it for background subtraction.

### Example

```
h.load_dark(166) # load dark run 166
```

**find\_curvature**(runNB, proposal=None, plot=True, args=None, \*\*kwargs)

find the curvature correction coefficients

The *hRIXS* has some aberrations which leads to the spectroscopic lines being curved on the detector. We approximate these aberrations with a parabola for later correction.

Load a run and determine the curvature. The curvature is set in *self*, and returned as a pair of floats.

#### Parameters

- **runNB** (*int*) – the run number to use
- **proposal** (*int*) – the proposal to use, default to the current proposal
- **plot** (*bool*) – whether to plot the found curvature onto the data
- **args** (*pair of float, optional*) – a starting value to prime the fitting routine

### Example

```
h.find_curvature(155) # use run 155 to fit the curvature
```

**centroid\_one**(image)

find the position of photons with sub-pixel precision

A photon is supposed to have hit the detector if the intensity within a 2-by-2 square exceeds a threshold. In this case the position of the photon is calculated as the center-of-mass in a 4-by-4 square.

Return the list of x, y coordinate pairs, corrected by the curvature.

**centroid\_two**(*image, energy*)

determine position of photon hits on detector

The algorithm is taken from the ESRF RIXS toolbox. The thresholds for determining photon hits are given by the incident photon energy

The function returns arrays containing the single and double hits as x and y coordinates

**centroid**(*data, bins=None, method='auto'*)

calculate a spectrum by finding the centroid of individual photons

This takes the *xarray.Dataset data* and returns a copy of it, with a new *xarray.DataArray* named *spectrum* added, which contains the energy spectrum calculated for each hRIXS image.

Added a key for switching between algorithms choices are “auto” and “manual” which selects for method for determining whether thresholds there is a photon hit. It changes whether *centroid\_one* or *centroid\_two* is used.

**Example**

```
h.centroid(data) # find photons in all images of the run data.spectrum[0, :].plot() # plot the spectrum of the first image
```

**parabola**(*x*)**integrate**(*data*)

calculate a spectrum by integration

This takes the *xarray data* and returns a copy of it, with a new *dataarray* named *spectrum* added, which contains the energy spectrum calculated for each hRIXS image.

First the energy that corresponds to each pixel is calculated. Then all pixels within an energy range are summed, where the intensity of one pixel is distributed among the two energy ranges the pixel spans, proportionally to the overlap between the pixel and bin energy ranges.

The resulting data is normalized to one pixel, so the average intensity that arrived on one pixel.

**Example**

```
h.integrate(data) # create spectrum by summing pixels data.spectrum[0, :].plot() # plot the spectrum of the first image
```

**aggregator**(*da, dim*)**aggregate**(*ds, var=None, dim='trainId'*)

aggregate (i.e. mostly sum) all data within one dataset

take all images in a dataset and aggregate them and their metadata. For images, spectra and normalizations that means adding them, for others (e.g. delays) adding would not make sense, so we treat them properly. The aggregation functions of each variable are defined in the *aggregators* attribute of the class. If *var* is specified, group the dataset by *var* prior to aggregation. A new variable “counts” gives the number of frames aggregated in each group.

**Parameters**

- **ds** (*xarray Dataset*) – the dataset containing RIXS data



- **var** (*string*) – One of the variables in the dataset. If var is specified, the dataset is grouped by var prior to aggregation. This is useful for sorting e.g. a dataset that contains multiple delays.
- **dim** (*string*) – the dimension over which to aggregate the data

### Example

```
h.centroid(data) # create spectra from finding photons
agg = h.aggregate(data) # sum all spectra
agg.spectrum.plot() # plot the resulting spectrum
```

```
agg2 = h.aggregate(data, 'hRIXS_delay') # group data by delay
agg2.spectrum[0, :].plot() # plot the spectrum for first value
```

```
aggregate_ds(ds, dim='trainId')
```

```
normalize(data, which='hRIXS_norm')
```

Adds a ‘normalized’ variable to the dataset defined as the ration between ‘spectrum’ and ‘which’

#### Parameters

- **data** (*xarray Dataset*) – the dataset containing hRIXS data
- **which** (*string, default="hRIXS\_norm"*) – one of the variables of the dataset, usually “hRIXS\_norm” or “counts”

```
class toolbox_scs.MaranaX(*args, **kwargs)
```

Bases: *hRIXS*

A spin-off of the hRIXS class: with parallelized centroiding

```
NUM_MAX_HITS = 30
```

```
centroid(data, bins=None, **kwargs)
```

calculate a spectrum by finding the centroid of individual photons

This takes the *xarray.Dataset* data and returns a copy of it, with a new *xarray.DataArray* named *spectrum* added, which contains the energy spectrum calculated for each hRIXS image.

Added a key for switching between algorithms choices are “auto” and “manual” which selects for method for determining whether thresholds there is a photon hit. It changes whether centroid\_one or centroid\_two is used.

### Example

```
h.centroid(data) # find photons in all images of the run
data.spectrum[0, :].plot() # plot the spectrum of the first image
```

```
_centroid_tb_map(_, index, data)
```

```
_centroid_map(index, *, image, energy)
```

```
_centroid_task(index, image, energy)
```

```
_histogram_task(index, total, double, default_range)
```

**centroid\_from\_run**(*runNB*, *proposal=None*, *extra\_fields=()*, *drop\_first=False*, *subset=None*, *bins=None*, *return\_hits=False*)

A combined function of *from\_run()* and *centroid()*, which uses *extra\_data* and *pasha* to avoid bulk loading of files.

**\_centroid\_ed\_map**(*\_*, *index*, *trainId*, *data*)

**static \_mnemo\_to\_prop**(*mnemo*)

**\_is\_mnemo\_in\_run**(*mnemo*, *run*)

**toolbox\_scs.get\_pes\_params**(*run*, *channel=None*)

Extract PES parameters for a given *extra\_data* DataCollection. Parameters are gas, binding energy, retardation voltages or all voltages of the MPOD.

**Parameters**

- **run** (*extra\_data.DataCollection*) – DataCollection containing the digitizer data
- **channel** (*str*) – Channel name or PES mnemonic, e.g. ‘2A’ or ‘PES\_1Craw’. If None, or if the channel is not found in the data, the retardation voltage for all channels is retrieved.

**Returns**

**params** – dictionary of PES parameters

**Return type**

dict

**toolbox\_scs.get\_pes\_tof**(*proposal*, *runNB*, *mnemonic*, *start=0*, *origin=None*, *width=None*, *subtract\_baseline=False*, *baseStart=None*, *baseWidth=40*, *merge\_with=None*)

Extracts time-of-flight spectra from raw digitizer traces. The spectra are aligned by pulse Id using the SASE 3 bunch pattern. If origin is not None, a time coordinate in nanoseconds ‘time\_ns’ is computed and added to the DataArray.

**Parameters**

- **proposal** (*int*) – The proposal number.
- **runNB** (*int*) – The run number.
- **mnemonic** (*str*) – mnemonic for PES, e.g. “PES\_2Araw”.
- **start** (*int*) – starting sample of the first spectrum in the raw trace.
- **origin** (*int*) – sample of the trace that corresponds to time-of-flight origin, also called prompt. Used to compute the ‘time\_ns’ coordinates. If None, computation of ‘time\_ns’ is skipped.
- **width** (*int*) – number of samples per spectra. If None, the number of samples for 4.5 MHz repetition rate is used.
- **subtract\_baseline** (*bool*) – If True, subtract baseline defined by baseStart and baseWidth to each spectrum.
- **baseStart** (*int*) – starting sample of the baseline.
- **baseWidth** (*int*) – number of samples to average (starting from baseStart) for baseline calculation.
- **merge\_with** (*xarray Dataset*) – If provided, the resulting Dataset will be merged with this one.

**Returns**

**pes** – DataArray containing the PES time-of-flight spectra.

**Return type**

xarray DataArray

**Example**

```
>>> import toolbox_scs as tb
>>> import toolbox_scs.detectors as tbdet
>>> proposal, runNB = 900447, 12
>>> pes = tbdet.get_pes_tof(proposal, runNB, 'PES_2Araw',
>>>                          start=2557, origin=76)
```

`toolbox_scs.save_pes_avg_traces(proposal, runNB, channels=None, subdir='usr/processed_runs')`

Save average traces of PES into an h5 file.

**Parameters**

- **proposal** (*int*) – The proposal number.
- **runNB** (*int*) – The run number.
- **channels** (*str or list*) – The PES channels or mnemonics, e.g. '2A', ['2A', '3C'], ['PES\_1Araw', 'PES\_4Draw', '3B']
- **subdir** (*str*) – subdirectory. The data is stored in <proposal path>/<subdir>/r{runNB:04d}/f{r{runNB:04d}}-pes-data.h5'
- **Output** –
- -----
- **traces.** (*xarray Dataset saved in a h5 file containing the PES average*)
- 

`toolbox_scs.load_pes_avg_traces(proposal, runNB, channels=None, subdir='usr/processed_runs')`

Load existing PES average traces.

**Parameters**

- **proposal** (*int*) – The proposal number.
- **runNB** (*int*) – The run number.
- **channels** (*str or list*) – The PES channels or mnemonics, e.g. '2A', ['2A', '3C'], ['PES\_1Araw', 'PES\_4Draw', '3B']
- **subdir** (*str*) – subdirectory. The data is stored in <proposal path>/<subdir>/r{runNB:04d}/f{r{runNB:04d}}-pes-data.h5'
- **Output** –
- -----
- **ds** (*xarray Dataset*) – dataset containing the PES average traces.

`class toolbox_scs.Viking(proposalNB)`

The Viking analysis (spectrometer used in combination with Andor Newton camera)

The objects of this class contain the meta-information about the settings of the spectrometer, not the actual data, except possibly a dark image for background subtraction.

The actual data is loaded into *xarray*'s via the method *from\_run()*, and stays there.

### PROPOSAL

the number of the proposal

**Type**  
int

### X\_RANGE

the slice to take in the non-dispersive direction, in pixels. Defaults to the entire width.

**Type**  
slice

### Y\_RANGE

the slice to take in the energy dispersive direction

**Type**  
slice

### USE\_DARK

whether to do dark subtraction. Is initially *False*, magically switches to *True* if a dark has been loaded, but may be reset.

**Type**  
bool

### ENERGY\_CALIB

The 2nd degree polynomial coefficients for calibration from pixel to energy. Defaults to [0, 1, 0] (no calibration applied).

**Type**  
1D array (len=3)

### BL\_POLY\_DEG

the degree of the polynomial used for baseline subtraction. Defaults to 1.

**Type**  
int

### BL\_SIGNAL\_RANGE

the dispersive-axis range, defined by an interval [min, max], to avoid when fitting a polynomial for baseline subtraction. Multiple ranges can be provided in the form [[min1, max1], [min2, max2], ...].

**Type**  
list

### FIELDS

the fields to be loaded from the data. Add additional fields if so desired.

**Type**  
list of str

### Example

```
proposal = 2953 v = Viking(proposal) v.X_RANGE = slice(0, 1900) v.Y_RANGE = slice(38, 80)
v.ENERGY_CALIB = [1.47802667e-06, 2.30600328e-02, 5.15884589e+02] v.BL_SIGNAL_RANGE = [500,
545]
```

```
set_params(**params)
```

```
get_params(*params)
```

```
from_run(runNB, add_attrs=True)
```

load a run

Load the run *runNB*. A thin wrapper around *toolbox\_scs.load*.

#### Parameters

- **runNB** (*int*) – the run number
- **add\_attrs** (*bool*) – if True, adds the camera parameters as attributes to the dataset (see `get_camera_params()`)
- **Output** –
- -----
- **ds** (*xarray Dataset*) – the dataset containing the camera images

### Example

```
data = v.from_run(145) # load run 145
```

```
data1 = v.from_run(145) # load run 145 data2 = v.from_run(155) # load run 155
data = xarray.concat([data1, data2], 'trainId') # combine both
```

```
load_dark(runNB=None)
```

```
integrate(data)
```

This function calculates the mean over the non-dispersive dimension to create a spectrum. If the camera parameters are known, the spectrum is multiplied by the number of photoelectrons per ADC count. A new variable “spectrum” is added to the data.

```
get_camera_gain(run)
```

Get the preamp gain of the camera in the Viking spectrometer for a specified run.

#### Parameters

- **run** (*extra\_data DataCollection*) – information on the run
- **Output** –
- -----
- **gain** (*int*) –

```
e_per_counts(run, gain=None)
```

Conversion factor from camera digital counts to photoelectrons per count. The values can be found in the camera datasheet (Andor Newton) but they have been slightly corrected for High Sensitivity mode after analysis of runs 1204, 1207 and 1208, proposal 2937.

#### Parameters

- **run** (*extra\_data DataCollection*) – information on the run

- **gain** (*int*) – the camera preamp gain
- **Output** –
- -----
- **ret** (*float*) – photoelectrons per count

**get\_camera\_params**(*run*)

**removePolyBaseline**(*data*)

Removes a polynomial baseline to a spectrum, assuming a fixed position for the signal.

#### Parameters

- **data** (*xarray Dataset*) – The Viking data containing the variable “spectrum”
- **Output** –
- -----
- **data** – the original dataset with the added variable “spectrum\_nobl” containing the baseline subtracted spectra.

**xas**(*data, data\_ref, thickness=1, plot=False, plot\_errors=True, xas\_ylim=(-1, 3)*)

Given two independent datasets (one with sample and one reference), this calculates the average XAS spectrum (absorption coefficient), associated standard deviation and standard error. The absorption coefficient is defined as  $-\log(I_t/I_0)/\text{thickness}$ .

#### Parameters

- **data** (*xarray Dataset*) – the dataset containing the spectra with sample
- **data\_ref** (*xarray Dataset*) – the dataset containing the spectra without sample
- **thickness** (*float*) – the thickness used for the calculation of the absorption coefficient
- **plot** (*bool*) – If True, plot the resulting average spectra.
- **plot\_errors** (*bool*) – If True, adds the 95% confidence interval on the spectra.
- **xas\_ylim** (*tuple or list of float*) – the y limits for the XAS plot.
- **Output** –
- -----
- **xas** (*xarray Dataset*) – the dataset containing the computed XAS quantities:  $I_0$ ,  $I_t$ ,  $\text{absorptionCoef}$  and their associated errors.

**calibrate**(*runList, plot=True*)

This routine determines the calibration coefficients to translate the camera pixels into energy in eV. The Viking spectrometer is calibrated using the beamline monochromator: runs with various monochromatized photon energy are recorded and their peak position on the detector are determined by Gaussian fitting. The energy vs. position data is then fitted to a second degree polynomial.

#### Parameters

- **runList** (*list of int*) – the list of runs containing the monochromatized spectra
- **plot** (*bool*) – if True, the spectra, their Gaussian fits and the calibration curve are plotted.
- **Output** –
- -----
- **energy\_calib** (*np. array*) – the calibration coefficients (2nd degree polynomial)

`toolbox_scs.calibrate_xgm(run, data, xgm='SCS', plot=False)`

Calculates the calibration factor F between the photon flux (slow signal) and the fast signal (pulse-resolved) of the sase 3 pulses. The calibrated fast signal is equal to the uncalibrated one multiplied by F.

#### Parameters

- **run** (*extra\_data.DataCollection*) – DataCollection containing the digitizer data.
- **data** (*xarray Dataset*) – dataset containing the pulse-resolved sase 3 signal, e.g. ‘SCS\_SA3’
- **xgm** (*str*) – one in {‘XTD10’, ‘SCS’}
- **plot** (*bool*) – If True, shows a plot of the photon flux, averaged fast signal and calibrated fast signal.

#### Returns

F – calibration factor F defined as: calibrated XGM [microJ] = F \* fast XGM array (‘SCS\_SA3’ or ‘XTD10\_SA3’)

#### Return type

float

#### Example

```
>>> import toolbox_scs as tb
>>> import toolbox_scs.detectors as tbdet
>>> run, data = tb.load(900074, 69, ['SCS_XGM'])
>>> ds = tbdet.get_xgm(run, merge_with=data)
>>> F = tbdet.calibrate_xgm(run, ds, plot=True)
>>> # Add calibrated XGM to the dataset:
>>> ds['SCS_SA3_uJ'] = F * ds['SCS_SA3']
```

`toolbox_scs.get_xgm(run, mnemonics=None, merge_with=None, indices=slice(0, None))`

Load and/or computes XGM data. Sources can be loaded on the fly via the mnemonics argument, or processed from an existing dataset (*merge\_with*). The bunch pattern table is used to assign the pulse id coordinates if the number of pulses has changed during the run.

#### Parameters

- **run** (*extra\_data.DataCollection*) – DataCollection containing the xgm data.
- **mnemonics** (*str or list of str*) – mnemonics for XGM, e.g. “SCS\_SA3” or [“XTD10\_XGM”, “SCS\_XGM”]. If None, defaults to “SCS\_SA3” in case no *merge\_with* dataset is provided.
- **merge\_with** (*xarray Dataset*) – If provided, the resulting Dataset will be merged with this one. The XGM variables of *merge\_with* (if any) will also be computed and merged.
- **indices** (*slice, list, 1D array*) – Pulse indices of the XGM array in case bunch pattern is missing.

#### Returns

merged with Dataset *merge\_with* if provided.

#### Return type

xarray Dataset with pulse-resolved XGM variables aligned,

### Example

```
>>> import toolbox_scs as tb
>>> run, ds = tb.load(2212, 213, 'SCS_SA3')
>>> ds['SCS_SA3']
```

`toolbox_scs.concatenateRuns(runs)`

Sorts and concatenate a list of runs with identical data variables along the `trainId` dimension.

**Input:**

`runs`: (list) the xarray Datasets to concatenate

**Output:**

a concatenated xarray Dataset

`toolbox_scs.find_run_path(proposalNB, runNB, data='raw')`

Return the run path given the specified proposal and run numbers.

**Parameters**

- **proposalNB** ((*str*, *int*)) – proposal number e.g. ‘p002252’ or 2252
- **runNB** ((*str*, *int*)) – run number as integer
- **data** (*str*) – ‘raw’, ‘proc’ (processed) or ‘all’ (both ‘raw’ and ‘proc’) to access data from either or both of those folders. If ‘all’ is used, sources present in ‘proc’ overwrite those in ‘raw’. The default is ‘raw’.

**Returns**

**path** – The run path.

**Return type**

str

`toolbox_scs.get_array(run=None, mnemonic=None, stepsize=None, subset=None, data='raw',  
proposalNB=None, runNB=None)`

Loads one data array for the specified mnemonic and rounds its values to integer multiples of `stepsize` for consistent grouping (except for `stepsize=None`). Returns a 1D array of ones if mnemonic is set to None.

**Parameters**

- **run** (*extra\_data.DataCollection*) – DataCollection containing the data. Used if `proposalNB` and `runNB` are None.
- **mnemonic** (*str*) – Identifier of a single item in the mnemonic collection. None creates a dummy 1D array of ones with length equal to the number of trains.
- **stepsize** (*float*) – nominal stepsize of the array data - values will be rounded to integer multiples of this value.
- **subset** (slice or *extra\_data.by\_index* or **numpy.s\_**) – a subset of train that can be loaded with `extra_data.by_index[:5]` for the first 5 trains. If None, all trains are retrieved.
- **data** (*str* or *Sequence of str*) – ‘raw’, ‘proc’ (processed), or any other location relative to the proposal path with data per run to access. May also be ‘all’ (both ‘raw’ and ‘proc’) or a sequence of strings to load data from several locations, with later locations overwriting sources present in earlier ones. The default is ‘raw’.
- **proposalNB** ((*str*, *int*)) – proposal number e.g. ‘p002252’ or 2252.
- **runNB** ((*str*, *int*)) – run number e.g. 17 or ‘r0017’.



**Returns**

**data** – xarray DataArray containing rounded array values using the trainId as coordinate.

**Return type**

xarray.DataArray

**Raises**

**ToolBoxValueError** – Exception: Toolbox specific exception, indicating a non-valid mnemonic entry

**Example**

```
>>> import toolbox_scs as tb
>>> run = tb.open_run(2212, 235)
>>> mnemonic = 'PP800_PhaseShifter'
>>> data_PhaseShifter = tb.get_array(run, mnemonic, 0.5)
```

```
toolbox_scs.load(proposalNB=None, runNB=None, fields=None, data='all', display=False, validate=False,
                 subset=None, rois={}, extract_digitizers=True, extract_xgm=True, extract_bam=True,
                 bunchPattern='sase3', parallelize=True)
```

Load a run and extract the data. Output is an xarray with aligned trainIds.

**Parameters**

- **proposalNB** (*str*, *int*) – proposal number e.g. ‘p002252’ or 2252
- **runNB** (*str*, *int*) – run number as integer
- **fields** (*str*, *list of str*, *list of dict*) – list of mnemonics to load specific data such as “fastccd”, “SCS\_XGM”, or dictionaries defining a custom mnemonic such as {“extra”: {‘source’: ‘SCS\_CDIFFT\_MAG/SUPPLY/CURRENT’, ‘key’: ‘actual\_current.value’, ‘dim’: None}}
- **data** (*str or Sequence of str*) – ‘raw’, ‘proc’ (processed), or any other location relative to the proposal path with data per run to access. May also be ‘all’ (both ‘raw’ and ‘proc’) or a sequence of strings to load data from several locations, with later locations overwriting sources present in earlier ones. The default is ‘raw’.
- **display** (*bool*) – whether to show the run.info or not
- **validate** (*bool*) – whether to run extra-data-validate or not
- **subset** (*slice or extra\_data.by\_index or numpy.s\_*) – a subset of train that can be loaded with extra\_data.by\_index[:5] for the first 5 trains. If None, all trains are retrieved.
- **rois** (*dict*) – a dictionary of mnemonics with a list of rois definition and the desired names, for example: {‘fastccd’: {‘ref’: {‘roi’: by\_index[730:890, 535:720], ‘dim’: [‘ref\_x’, ‘ref\_y’]}, ‘sam’: {‘roi’:by\_index[1050:1210, 535:720], ‘dim’: [‘sam\_x’, ‘sam\_y’]}}
- **extract\_digitizers** (*bool*) – If True, extracts the peaks from digitizer variables and aligns the pulse Id according to the fadc\_bp bunch pattern.
- **extract\_xgm** (*bool*) – If True, extracts the values from XGM variables (e.g. ‘SCS\_SA3’, ‘XTD10\_XGM’) and aligns the pulse Id with the sase1 / sase3 bunch pattern.

- **extract\_bam** (*bool*) – If True, extracts the values from BAM variables (e.g. ‘BAM1932M’) and aligns the pulse Id with the sase3 bunch pattern.
- **bunchPattern** (*str*) – bunch pattern used to extract the Fast ADC pulses. A string or a dict as in:

```
{'FFT_PD2': 'sase3', 'ILH_I0': 'scs_ppl'}
```

Ignored if `extract_digitizers=False`.

- **parallelize** (*bool*) – from EXtra-Data: enable or disable opening files in parallel. Particularly useful if creating child processes is not allowed (e.g. in a daemonized multiprocessing.Process).

### Returns

**run, ds** – `extra_data.DataCollection` of the proposal and run number and an `xarray.Dataset` with aligned `trainIds` and `pulseIds`

### Return type

`DataCollection`, `xarray.Dataset`

### Example

```
>>> import toolbox_scs as tb
>>> run, data = tb.load(2212, 208, ['SCS_SA3', 'MCP2apd', 'nrj'])
```

`toolbox_scs.open_run(proposalNB, runNB, subset=None, **kwargs)`

Get `extra_data.DataCollection` in a given proposal. Wraps the `extra_data.open_run` routine and adds `subset` selection, out of convenience for the toolbox user. More information can be found in the `extra_data` documentation.

### Parameters

- **proposalNB** (*(str, int)*) – proposal number e.g. ‘p002252’ or 2252
- **runNB** (*(str, int)*) – run number e.g. 17 or ‘r0017’
- **subset** (slice or `extra_data.by_index` or `numpy.s_`) – a subset of train that can be loaded with `extra_data.by_index[:5]` for the first 5 trains. If `None`, all trains are retrieved.
- **\*\*kwargs** –
- -----
- **data** (*str*) – default -> ‘raw’
- **include** (*str*) – default -> ‘\*’

### Returns

**run** – `DataCollection` object containing information about the specified run. Data can be loaded using built-in class methods.

### Return type

`extra_data.DataCollection`

`toolbox_scs.run_by_path(path)`

Return specified run

Wraps the `extra_data.RunDirectory` routine, to ease its use for the `scs-toolbox` user.

### Parameters

**path** (*str*) – path to the run directory

**Returns**

**run** – DataCollection object containing information about the specified run. Data can be loaded using built-in class methods.

**Return type**

extra\_data.DataCollection

toolbox\_scs.**load\_run\_values**(*prop\_or\_run*, *runNB=None*, *which='mnemonics'*)

Load the run value for each mnemonic whose source is a CONTORL source (see extra-data DataCollection.get\_run\_value() for details)

**Parameters**

- **prop\_or\_run** (*extra\_data DataCollection or int*) – The run (DataCollection) to check for mnemonics. Alternatively, the proposal number (int), for which the runNB is also required.
- **runNB** (*int*) – The run number. Only used if the first argument is the proposal number.
- **which** (*str*) – ‘mnemonics’ or ‘all’. If ‘mnemonics’, only the run values for the ToolBox mnemonics are retrieved. If ‘all’, a compiled dictionary of all control sources run values is returned.
- **Output** –
- ----- –
- **run\_values** (*a dictionary containing the mnemonic or all run values.*) –

toolbox\_scs.**check\_data\_rate**(*run*, *fields=None*)

Calculates the fraction of train ids that contain data in a run.

**Parameters**

- **run** (*extra\_data DataCollection*) – the DataCollection associated to the data.
- **fields** (*str, list of str or dict*) – mnemonics to check. If None, all mnemonics in the run are checked. A custom mnemonic can be defined with a dictionary: {'extra': {'source': 'SCS\_CDIFFT\_MAG/SUPPLY/CURRENT', 'key': 'actual\_current.value'}}
- **Output** –
- ----- – ret: dictionary dictionary with mnemonic as keys and fraction of train ids that contain data as values.

toolbox\_scs.**\_\_all\_\_**

toolbox\_scs.**extractBunchPattern**(*bp\_table=None*, *key='sase3'*, *runDir=None*)

generate the bunch pattern and number of pulses of a source directly from the bunch pattern table and not using the MDL device BUNCH\_DECODER. This is inspired by the eufel\_bunch\_pattern package, [https://git.xfel.eu/gitlab/karaboDevices/eufel\\_bunch\\_pattern](https://git.xfel.eu/gitlab/karaboDevices/eufel_bunch_pattern) Inputs:

**bp\_table: DataArray corresponding to the mnemonics “bunchPatternTable”.**

If None, the bunch pattern table is loaded using runDir.

key: str, ['sase1', 'sase2', 'sase3', 'scs\_ppl'] runDir: extra-data DataCollection. Required only if bp\_table is None.

**Outputs:**

bunchPattern: DataArray containing indices of the sase/laser pulses for each train npulses: DataArray containing the number of pulses for each train matched: 2-D DataArray mask (trainId x 2700), True where 'key' has pulses

`toolbox_scs.get_sase_pId(run, loc='sase3', run_mnemonics=None, bpt=None, merge_with=None)`

Returns the pulse Ids of the specified *loc* during a run. If the number of pulses has changed during the run, it loads the bunch pattern table and extract all pulse Ids used.

**Parameters**

- **run** (*extra\_data.DataCollection*) – DataCollection containing the data.
- **loc** (*str*) – The location where to check: {'sase1', 'sase3', 'scs\_ppl' }
- **run\_mnemonics** (*dict*) – the mnemonics for the run (see *menonics\_for\_run*)
- **bpt** (*2D-array*) – The bunch pattern table. Used only if the number of pulses has changed. If None, it is loaded on the fly.
- **merge\_with** (*xarray.Dataset*) – dataset that may contain the bunch pattern table to use in case the number of pulses has changed. If merge\_with does not contain the bunch pattern table, it is loaded and added as a variable 'bunchPatternTable' to merge\_with.

**Returns**

**pulseIds** – the pulse ids at the specified location. Returns None if the mnemonic is not in the run.

**Return type**

np.array

`toolbox_scs.npulses_has_changed(run, loc='sase3', run_mnemonics=None)`

Checks if the number of pulses has changed during the run for a specific location *loc* (='sase1', 'sase3', 'scs\_ppl' or 'laser') If the source is not found in the run, returns True.

**Parameters**

- **run** (*extra\_data.DataCollection*) – DataCollection containing the data.
- **loc** (*str*) – The location where to check: {'sase1', 'sase3', 'scs\_ppl' }
- **run\_mnemonics** (*dict*) – the mnemonics for the run (see *menonics\_for\_run*)

**Returns**

**ret** – True if the number of pulses has changed or the source was not found, False if the number of pulses did not change.

**Return type**

bool

`toolbox_scs.pulsePatternInfo(data, plot=False)`

display general information on the pulse patterns operated by SASE1 and SASE3. This is useful to track changes of number of pulses or mode of operation of SASE1 and SASE3. It also determines which SASE comes first in the train and the minimum separation between the two SASE sub-trains.

**Inputs:**

**data:** xarray Dataset containing pulse pattern info from the bunch decoder MDL: {'sase1, sase3', 'npulses\_sase1', 'npulses\_sase3'} **plot:** bool enabling/disabling the plotting of the pulse patterns

**Outputs:**

print of pulse pattern info. If plot==True, plot of the pulse pattern.

`toolbox_scs.repRate(data=None, runNB=None, proposalNB=None, key='sase3')`

Calculates the pulse repetition rate (in kHz) in sase according to the bunch pattern and assuming a grid of 4.5 MHz.

**Inputs:**

data: xarray Dataset containing pulse pattern, needed if runNB is none  
 runNB: int or str, run number. Needed if data is None  
 proposal: int or str, proposal where to find the run. Needed if data is None  
 key: str in [sase1, sase2, sase3, scs\_ppl], source for which the repetition rate is calculated

**Output:**

f: repetition rate in kHz

`toolbox_scs.is_sase_3(bpt)`

Check for presence of a SASE3 pulse.

**Parameters**

**bpt** (*numpy array*, *xarray DataArray*) – The bunch pattern data.

**Returns**

**boolean** – true if SASE3 pulse is present.

**Return type**

*numpy array*, *xarray DataArray*

`toolbox_scs.is_sase_1(bpt)`

Check for presence of a SASE1 pulse.

**Parameters**

**bpt** (*numpy array*, *xarray DataArray*) – The bunch pattern data.

**Returns**

**boolean** – true if SASE1 pulse is present.

**Return type**

*numpy array*, *xarray DataArray*

`toolbox_scs.is_ppl(bpt)`

Check for presence of pp-laser pulse.

**Parameters**

**bpt** (*numpy array*, *xarray DataArray*) – The bunch pattern data.

**Returns**

**boolean** – true if pp-laser pulse is present.

**Return type**

*numpy array*, *xarray DataArray*

`toolbox_scs.is_pulse_at(bpt, loc)`

Check for presence of a pulse at the location provided.

**Parameters**

- **bpt** (*numpy array*, *xarray DataArray*) – The bunch pattern data.
- **loc** (*str*) – The location where to check: {'sase1', 'sase3', 'scs\_ppl' }

**Returns**

**boolean** – true if a pulse is present at *loc*.

**Return type**

numpy array, xarray DataArray

`toolbox_scs.degToRelPower(x, theta0=0)`

converts a half-wave plate position in degrees into relative power between 0 and 1. Inputs:

x: array-like positions of half-wave plate, in degrees theta0: position for which relative power is zero

**Output:**

array-like relative power

`toolbox_scs.positionToDelay(pos, origin=0, invert=True, reflections=1)`

converts a motor position in mm into optical delay in picosecond Inputs:

pos: array-like delay stage motor position origin: motor position of time zero in mm invert: bool, inverts the sign of delay if True reflections: number of bounces in the delay stage

**Output:**

delay in picosecond

`toolbox_scs.delayToPosition(delay, origin=0, invert=True, reflections=1)`

converts an optical delay in picosecond into a motor position in mm Inputs:

delay: array-like delay in ps origin: motor position of time zero in mm invert: bool, inverts the sign of delay if True reflections: number of bounces in the delay stage

**Output:**

delay in picosecond

`toolbox_scs.fluenceCalibration(hwp, power_mW, npulses, w0x, w0y=None, train_rep_rate=10, fit_order=1, plot=True, xlabel='HWP [%']')`

Given a measurement of relative powers or half wave plate angles and averaged powers in mW, this routine calculates the corresponding fluence and fits a polynomial to the data.

**Parameters**

- **hwp** (*array-like (N)*) – angle or relative power from the half wave plate
- **power\_mW** (*array-like (N)*) – measured power in mW by powermeter
- **npulses** (*int*) – number of pulses per train during power measurement
- **w0x** (*float*) – radius at  $1/e^2$  in x-axis in meter
- **w0y** (*float, optional*) – radius at  $1/e^2$  in y-axis in meter. If None,  $w0y=w0x$  is assumed.
- **train\_rep\_rate** (*float*) – repetition rate of the FEL, by default equals to 10 Hz.
- **fit\_order** (*int*) – order of the polynomial fit
- **plot** (*bool*) – Plot the results if True
- **xlabel** (*str*) – xlabel for the plot
- **Output** –  
-----
- **F** (*ndarray (N)*) – fluence in  $\text{mJ}/\text{cm}^2$
- **fit\_F** (*ndarray*) – coefficients of the fluence polynomial fit

- **E** (*ndarray* (*N*)) – pulse energy in microJ
- **fit\_E** (*ndarray*) – coefficients of the fluence polynomial fit

`toolbox_scs.align_ol_to_fel_pId(ds, ol_dim='ol_pId', fel_dim='sa3_pId', offset=0, fill_value=np.nan)`

Aligns the optical laser (OL) pulse Ids to the FEL pulse Ids. The new OL coordinates are calculated as `ds[ol_dim] + ds[fel_dim][0] + offset`. The `ol_dim` is then removed, and if the number of OL and FEL pulses are different, the missing values are replaced by `fill_value` (NaN by default).

#### Parameters

- **ds** (*xarray.Dataset*) – Dataset containing both OL and FEL dimensions
- **ol\_dim** (*str*) – name of the OL dimension
- **fel\_dim** (*str*) – name of the FEL dimension
- **offset** (*int*) – offset added to the OL pulse Ids.
- **fill\_value** (*(scalar or dict-like, optional)*) – Value to use for newly missing values. If a dict-like, maps variable names to fill values. Use a data array's name to refer to its values.
- **Output** –
- ----- –
- **ds** – The newly aligned dataset

`toolbox_scs.get_undulator_config(run, park_pos=62.0, plot=True)`

Extract the undulator cells configuration from a given run. The gap size and K factor as well as the magnetic chicane delay and photon energy of colors 1, 2 and 3 are compiled into an *xarray Dataset*.

Note: This function looks at run control values, it does not reflect any change of values during the run. Do not use to extract configuration when scanning the undulator.

#### Parameters

- **run** (*EXtra-Data DataCollection*) – The run containing the undulator information
- **park\_pos** (*float, optional*) – The parked position of a cell (i.e. when fully opened)
- **plot** (*bool, optional*) – If True, plot the undulator cells configuration

#### Returns

**cells** – The resulting dataset of the undulator configuration

#### Return type

*xarray Dataset*

`toolbox_scs.mnemonics_for_run(prop_or_run, runNB=None)`

Returns the available ToolBox mnemonics for a given *extra\_data DataCollection*, or a given proposal + run number.

#### Parameters

- **prop\_or\_run** (*extra\_data DataCollection or int*) – The run (*DataCollection*) to check for mnemonics. Alternatively, the proposal number (*int*), for which the `runNB` is also required.
- **runNB** (*int*) – The run number. Only used if the first argument is the proposal number.

#### Returns

**mnemonics** – The dictionary of mnemonics that are available in the run.

#### Return type

*dict*

## Example

```
>>> import toolbox_scs as tb
>>> tb.mnemonics_for_run(2212, 213)
```

`toolbox_scs.__all__`

`toolbox_scs.xas`(*nrun*, *bins=None*, *Iokey='SCS\_SA3'*, *Itkey='MCP3peaks'*, *nrjkey='nrj'*, *Iooffset=0*, *plot=False*, *fluorescence=False*)

Compute the XAS spectra from a xarray *nrun*.

### Inputs:

*nrun*: xarray of SCS data bins: an array of bin-edges or an integer number of desired bins or a float for the desired bin width.

*Iokey*: string for the Io fields, typically 'SCS\_XGM' *Itkey*: string for the It fields, typically 'MCP3apd'

*nrjkey*: string for the nrj fields, typically 'nrj' *Iooffset*: offset to apply on Io *plot*: boolean, displays a XAS spectrum if True *fluorescence*: boolean, if True, absorption is the ratio,

if False, absorption is negative log

### Outputs:

#### a dictionary containing:

*nrj*: the bin centers *muA*: the absorption sigma *A*: standard deviation on the absorption *sterrA*: standard

error on the absorption *muIo*: the mean of the Io counts: the number of events in each bin

`toolbox_scs.xasxmcd`(*dataP*, *dataN*)

Compute XAS and XMCD from data with both magnetic field direction Inputs:

*dataP*: structured array for positive field *dataN*: structured array for negative field

### Outputs:

*xas*: structured array for the sum *xmcd*: structured array for the difference

**class** `toolbox_scs.parameters`(*proposal*, *darkrun*, *run*, *module*, *gain*, *drop\_intra\_darks=True*)

Parameters contains all input parameters for the BOZ corrections.

This is used in beam splitting off-axis zone plate spectroscopy analysis as well as the during the determination of correction parameters themselves to ensure they can be reproduced.

## Inputs

*proposal*: int, proposal number *darkrun*: int, run number for the dark run *run*: int, run number for the data run

*module*: int, DSSC module number *gain*: float, number of ph per bin *drop\_intra\_darks*: drop every second DSSC frame

**dask\_load\_persistently**(*dark\_data\_size\_Gb=None*, *data\_size\_Gb=None*)

Load dask data array in memory.



### Inputs

**dark\_data\_size\_Gb:** float, optional size of dark to load in memory, in Gb

data\_size\_Gb: float, optional size of data to load in memory, in Gb

**use\_gpu()**

**set\_mask(arr)**

Set mask of bad pixels.

### Inputs

**arr:** either a boolean array of a DSSC module image or a list of bad pixel indices

**get\_mask()**

Get the boolean array bad pixel of a DSSC module.

**get\_mask\_idx()**

Get the list of bad pixel indices.

**flat\_field\_guess(guess=None)**

Set the flat-field guess parameter for the fit and returns it.

### Inputs

**guess:** a list of 8 floats, the 4 first to define the plane

$ax+by+cz+d=0$  for 'n' beam and the 4 last for the 'p' beam in case mirror symmetry is disabled

**set\_flat\_field(ff\_params, ff\_type='plane', prod\_th=None, ratio\_th=None)**

Set the flat-field plane definition.

### Inputs

ff\_params: list of parameters ff\_type: string identifying the type of flat field normalization, default is 'plane'.

**get\_flat\_field()**

Get the flat-field plane definition.

**set\_Fnl(Fnl)**

Set the non-linear correction function.

**get\_Fnl()**

Get the non-linear correction function.

**save(path='./')**

Save the parameters as a JSON file.

### Inputs

path: str, where to save the file, default to './'

**classmethod load**(fname)

Load parameters from a JSON file.

### Inputs

fname: string, name a the JSON file to load

**\_\_str\_\_**()

Return str(self).

**toolbox\_scs.get\_roi\_pixel\_pos**(roi, params)

Compute fake or real pixel position of an roi from roi center.

### Inputs:

roi: dictionary params: parameters

### Returns:

X, Y: 1-d array of pixel position.

**toolbox\_scs.bad\_pixel\_map**(params)

Compute the bad pixels map.

### Inputs

params: parameters

**rtype**

bad pixel map

**toolbox\_scs.inspect\_dark**(arr, mean\_th=(None, None), std\_th=(None, None))

Inspect dark run data and plot diagnostic.

### Inputs

arr: dask array of reshaped dssc data (trainId, pulseId, x, y) mean\_th: tuple of threshold (low, high), default (None, None), to compute

a mask of good pixels for which the mean dark value lie inside this range

**std\_th: tuple of threshold (low, high), default (None, None), to compute a**

mask of bad pixels for which the dark std value lie inside this range

**returns**

fig

**rtype**  
matplotlib figure

`toolbox_scs.histogram_module(arr, mask=None)`

Compute a histogram of the 9 bits raw pixel values over a module.

### Inputs

arr: dask array of reshaped dssc data (trainId, pulseId, x, y) mask: optional bad pixel mask

**rtype**  
histogram

`toolbox_scs.inspect_histogram(arr, arr_dark=None, mask=None, extra_lines=False)`

Compute and plot a histogram of the 9 bits raw pixel values.

### Inputs

arr: dask array of reshaped dssc data (trainId, pulseId, x, y) arr: dask array of reshaped dssc dark data (trainId, pulseId, x, y) mask: optional bad pixel mask extra\_lines: boolean, default False, plot extra lines at period values

**returns**

- **(h, hd)** (*histogram of arr, arr\_dark*)
- *figure*

`toolbox_scs.find_rois(data_mean, threshold, extended=False)`

Find rois from 3 beams configuration.

### Inputs

data\_mean: dark corrected average image threshold: threshold value to find beams extended: boolean, True to define additional ASICS based rois

**returns**  
**rois**

**rtype**  
dictionary of rois

`toolbox_scs.find_rois_from_params(params)`

Find rois from 3 beams configuration.

### Inputs

params: parameters

**returns**  
**rois**

**rtype**  
dictionnary of rois

`toolbox_scs.inspect_rois(data_mean, rois, threshold=None, allrois=False)`

Find rois from 3 beams configuration from mean module image.

### Inputs

`data_mean`: mean module image threshold: float, default None, threshold value used to detect beams boundaries

**allrois**: boolean, default False, plot all rois defined in rois or only the main ones (['n', '0', 'p'])

**rtype**  
matplotlib figure

`toolbox_scs.compute_flat_field_correction(rois, params, plot=False)`

`toolbox_scs.inspect_flat_field_domain(avg, rois, prod_th, ratio_th, vmin=None, vmax=None)`

Extract beams roi from average image and compute the ratio.

### Inputs

**avg**: module average image with no saturated shots for the flat-field determination

`rois`: dictionary or ROIs `prod_th`, `ratio_th`: tuple of floats for low and high threshold on product and ratio

`vmin`: imshow vmin level, default None will use 5 percentile value `vmax`: imshow vmax level, default None will use 99.8 percentile value

#### returns

- **fig** (matplotlib figure plotted)
- **domain** (a tuple (n\_m, p\_m) of domain for the 'n' and 'p' order)

`toolbox_scs.inspect_plane_fitting(avg, rois, domain=None, vmin=None, vmax=None)`

`toolbox_scs.plane_fitting_domain(avg, rois, prod_th, ratio_th)`

Extract beams roi, compute their ratio and the domain.

### Inputs

**avg**: module average image with no saturated shots for the flat-field determination

**rois**: dictionary or rois containing the 3 beams ['n', '0', 'p'] with '0' as the reference beam in the middle

**prod\_th**: float tuple, low and high threshold level to determine the plane fitting domain on the product image of the orders

**ratio\_th**: float tuple, low and high threshold level to determine the plane fitting domain on the ratio image of the orders

**returns**

- **n** (*img ratio 'n'/0*)
- **n\_m** (*mask where the the product 'n'0 is higher than 5 indicting that the\**) – img ratio 'n'/0 is defined
- **p** (*img ratio 'p'/0*)
- **p\_m** (*mask where the the product 'p'0 is higher than 5 indicting that the\**) – img ratio 'p'/0 is defined

`toolbox_scs.plane_fitting(params)`

Fit the plane flat-field normalization.

**Inputs**

params: parameters

**returns**

**res** – defines the plane as  $a*x + b*y + c*z + d = 0$

**rtype**

the minimization result. The fitted vector  $res.x = [a, b, c, d]$

`toolbox_scs.ff_refine_crit(p, alpha, params, arr_dark, arr, tid, rois, mask, sat_level=511)`

Criteria for the `ff_refine_fit`.

**Inputs**

p: ff plane params: parameters arr\_dark: dark data arr: data tid: train id of arr data rois: ['n', '0', 'p', 'sat'] rois mask: mask fo good pixels sat\_level: integer, default 511, at which level pixel begin to saturate

**rtype**

sum of standard deviation on binned 0th order intensity

`toolbox_scs.ff_refine_fit(params, crit=ff_refine_crit)`

Refine the flat-field fit by minimizing data spread.

**Inputs**

params: parameters

**returns**

- **res** (*scipy minimize result. res.x is the optimized parameters*)
- **fitres** (*iteration index arrays of criteria results for*) – [alpha=0, alpha, alpha=1]

`toolbox_scs.nl_domain(N, low, high)`

Create the input domain where the non-linear correction defined.

### Inputs

N: integer, number of control points or intervals low: input values below or equal to low will not be corrected  
high: input values higher or equal to high will not be corrected

**rtype**

array of  $2^{**9}$  integer values with N segments

`toolbox_scs.nl_lut(domain, dy)`

Compute the non-linear correction.

### Inputs

**domain:** input domain where dy is defined. For zero no correction is defined. For non-zero value x, dy[x] is applied.

**dy:** a vector of deviation from linearity on control point homogeneously dispersed over 9 bits.

**returns**

**F\_INL** – lookup table with 9 bits integer input

**rtype**

default None, non linear correction function given as a

`toolbox_scs.nl_crit(p, domain, alpha, arr_dark, arr, tid, rois, mask, flat_field, sat_level=511, use_gpu=False)`

Criteria for the non linear correction.

### Inputs

p: vector of dy non linear correction domain: domain over which the non linear correction is defined alpha: float, coefficient scaling the cost of the correction function

in the criterion

arr\_dark: dark data arr: data tid: train id of arr data rois: ['n', '0', 'p', 'sat'] rois mask: mask fo good pixels

flat\_field: zone plate flat-field correction sat\_level: integer, default 511, at which level pixel begin to saturate

**returns**

- $(1.0 - \alpha) * err1 + \alpha * err2$ , where *err1* is the  $1e8$  times the mean of
- error squared from a transmission of 1.0 and *err2* is the sum of the square
- of the deviation from the ideal detector response.

`toolbox_scs.nl_crit_sk(p, domain, alpha, arr_dark, arr, tid, rois, mask, flat_field, sat_level=511, use_gpu=False)`

Non linear correction criteria, combining 'n' and 'p' as reference.

## Inputs

p: vector of dy non linear correction domain: domain over which the non linear correction is defined alpha: float, coefficient scaling the cost of the correction function

in the criterion

arr\_dark: dark data arr: data tid: train id of arr data rois: ['n', '0', 'p', 'sat'] rois mask: mask fo good pixels flat\_field: zone plate flat-field correction sat\_level: integer, default 511, at which level pixel begin to saturate

### returns

- $(1.0 - \alpha) * err1 + \alpha * err2$ , where *err1* is the  $1e8$  times the mean of
- error squared from a transmission of 1.0 and *err2* is the sum of the square
- of the deviation from the ideal detector response.

`toolbox_scs.nl_fit(params, domain, ff=None, crit=None)`

Fit non linearities correction function.

## Inputs

params: parameters domain: array of index ff: array, flat field correction crit: function, criteria function

### returns

- **res** (*scipy minimize result. res.x is the optimized parameters*)
- **fitres** (*iteration index arrays of criteria results for*) – [alpha=0, alpha, alpha=1]

`toolbox_scs.inspect_nl_fit(res_fit)`

Plot the progress of the fit.

## Inputs

res\_fit:

### rtype

matplotlib figure

`toolbox_scs.snr(sig, ref, methods=None, verbose=False)`

Compute mean, std and SNR from transmitted and IO signals.

## Inputs

sig: 1D signal samples ref: 1D reference samples methods: None by default or list of strings to select which methods to use.

Possible values are 'direct', 'weighted', 'diff'. In case of None, all methods will be calculated.

verbose: booleand, if True prints calculated values

### returns

- dictionary of [methods][value] where value is 'mu' for mean and 's' for
- standard deviation.

`toolbox_scs.inspect_Fnl(Fnl)`

Plot the correction function Fnl.

### Inputs

Fnl: non linear correction function lookup table

#### rtype

matplotlib figure

`toolbox_scs.inspect_correction(params, gain=None)`

Comparison plot of the different corrections.

### Inputs

params: parameters gain: float, default None, DSSC gain in ph/bin

#### rtype

matplotlib figure

`toolbox_scs.inspect_correction_sk(params, ff, gain=None)`

Comparison plot of the different corrections, combining 'n' and 'p'.

### Inputs

params: parameters gain: float, default None, DSSC gain in ph/bin

#### rtype

matplotlib figure

`toolbox_scs.load_dssc_module(proposalNB, runNB, moduleNB=15, subset=slice(None),  
drop_intra_darks=True, persist=False, data_size_Gb=None)`

Load single module dssc data as dask array.

### Inputs

proposalNB: proposal number runNB: run number moduleNB: default 15, module number subset: default slice(None), subset of trains to load drop\_intra\_darks: boolean, default True, remove intra darks from the data persist: default False, load all data persistently in memory data\_size\_Gb: float, if persist is True, can optionally restrict

the amount of data loaded for dark data and run data in Gb

#### returns

- **arr** (dask array of reshaped dssc data (trainId, pulseId, x, y))
- **tid** (array of train id number)

`toolbox_scs.average_module(arr, dark=None, ret='mean', mask=None, sat_roi=None, sat_level=300,  
F_INL=None)`

Compute the average or std over a module.



## Inputs

arr: dask array of reshaped dssc data (trainId, pulseId, x, y) dark: default None, dark to be subtracted ret: string, either 'mean' to compute the mean or 'std' to compute the

standard deviation

mask: default None, mask of bad pixels to ignore sat\_roi: roi over which to check for pixel with values larger than

sat\_level to drop the image from the average or std

sat\_level: int, minimum pixel value for a pixel to be considered saturated F\_INL: default None, non linear correction function given as a

lookup table with 9 bits integer input

### rtype

average or standard deviation image

`toolbox_scs.process_module(arr, tid, dark, rois, mask=None, sat_level=511, flat_field=None, F_INL=None, use_gpu=False)`

Process one module and extract roi intensity.

## Inputs

arr: dask array of reshaped dssc data (trainId, pulseId, x, y) tid: array of train id number dark: pulse resolved dark image to remove rois: dictionary of rois mask: default None, mask of ignored pixels sat\_level: integer, default 511, at which level pixel begin to saturate flat\_field: default None, flat-field correction F\_INL: default None, non-linear correction function given as a

lookup table with 9 bits integer input

### rtype

dataset of extracted pulse and train resolved roi intensities.

`toolbox_scs.process(Fmodel, arr_dark, arr, tid, rois, mask, flat_field, sat_level=511, use_gpu=False)`

Process dark and run data with corrections.

## Inputs

Fmodel: correction lookup table arr\_dark: dark data arr: data rois: ['n', '0', 'p', 'sat'] rois mask: mask of good pixels flat\_field: zone plate flat-field correction sat\_level: integer, default 511, at which level pixel begin to saturate

### rtype

roi extracted intensities

`toolbox_scs.inspect_saturation(data, gain, Nbins=200)`

Plot roi integrated histogram of the data with saturation

## Inputs

data: xarray of roi integrated DSSC data gain: nominal DSSC gain in ph/bin Nbins: number of bins for the histogram, by default 200

### returns

- **f** (*handle to the matplotlib figure*)
- **h** (*xarray of the histogram data*)

```
toolbox_scs.reflectivity(data, Iokey='FastADC5peaks', Irkey='FastADC3peaks',
                        delaykey='PP800_DelayLine', binWidth=0.05, positionToDelay=True,
                        origin=None, invert=False, pumpedOnly=False, alternateTrains=False,
                        pumpOnEven=True, Ioweights=False, plot=True, plotErrors=True, units='mm')
```

Computes the reflectivity  $R = 100 * (I_r/I_o[\text{pumped}] / I_r/I_o[\text{unpumped}] - 1)$  as a function of delay. Delay can be a motor position in mm or an optical delay in ps, with possibility to convert from position to delay. The default scheme is alternating pulses pumped/unpumped/... in each train, also possible are alternating trains and pumped only. If fitting is enabled, attempts a double exponential (default) or step function fit.

### Parameters

- **data** (*xarray Dataset*) – Dataset containing the Io, Ir and delay data
- **Iokey** (*str*) – Name of the Io variable
- **Irkey** (*str*) – Name of the Ir variable
- **delaykey** (*str*) – Name of the delay variable (motor position in mm or optical delay in ps)
- **binWidth** (*float*) – width of bin in units of delay variable
- **positionToDelay** (*bool*) – If True, adds a time axis converted from position axis according to origin and invert parameters. Ignored if origin is None.
- **origin** (*float*) – Position of time overlap, shown as a vertical line. Used if positionToDelay is True to convert position to time axis.
- **invert** (*bool*) – Used if positionToDelay is True to convert position to time axis.
- **pumpedOnly** (*bool*) – Assumes that all trains and pulses are pumped. In this case, Delta R is defined as Ir/Io.
- **alternateTrains** (*bool*) – If True, assumes that trains alternate between pumped and unpumped data.
- **pumpOnEven** (*bool*) – Only used if alternateTrains=True. If True, even trains are pumped, if False, odd trains are pumped.
- **Ioweights** (*bool*) – If True, computes the ratio of the means instead of the mean of the ratios Irkey/Iokey. Useful when dealing with large intensity variations.
- **plot** (*bool*) – If True, plots the results.
- **plotErrors** (*bool*) – If True, plots the 95% confidence interval.
- **Output** –
- ----- – xarray Dataset containing the binned Delta R, standard deviation, standard error, counts and delays, and the fitting results if full is True.

`toolbox_scs.knife_edge(ds, axisKey='scannerX', signalKey='FastADC4peaks', axisRange=None, p0=None, full=False, plot=False, display=False)`

Calculates the beam radius at  $1/e^2$  from a knife-edge scan by fitting with erfc function:  $f(x, x0, w0, a, b) = a * \text{erfc}(\text{np.sqrt}(2) * (x-x0)/w0) + b$  with  $w0$  the beam radius at  $1/e^2$  and  $x0$  the beam center.

#### Parameters

- **ds** (*xarray Dataset*) – dataset containing the detector signal and the motor position.
- **axisKey** (*str*) – key of the axis against which the knife-edge is performed.
- **signalKey** (*str*) – key of the detector signal.
- **axisRange** (*list of floats*) – edges of the scanning axis between which to apply the fit.
- **p0** (*list of floats, numpy 1D array*) – initial parameters used for the fit:  $x0$ ,  $w0$ ,  $a$ ,  $b$ . If `None`, a beam radius of 100 micrometers is assumed.
- **full** (*bool*) – If `False`, returns the beam radius and standard error. If `True`, returns the `popt`, `pcov` list of parameters and covariance matrix from `scipy.optimize.curve_fit`.
- **plot** (*bool*) – If `True`, plots the data and the result of the fit. Default is `False`.
- **display** (*bool*) – If `True`, displays info on the fit. `True` when `plot` is `True`, default is `False`.

#### Returns

error from the fit in mm. If `full` is `True`, returns parameters and covariance matrix from `scipy.optimize.curve_fit` function.

#### Return type

If `full` is `False`, tuple with beam radius at  $1/e^2$  in mm and standard

`toolbox_scs.__all__`

For reasons of readability, contributions preferably comply with the [PEP8](#) code structure guidelines.

The associated code checker, called ‘flake8’, can be installed via PyPi.



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