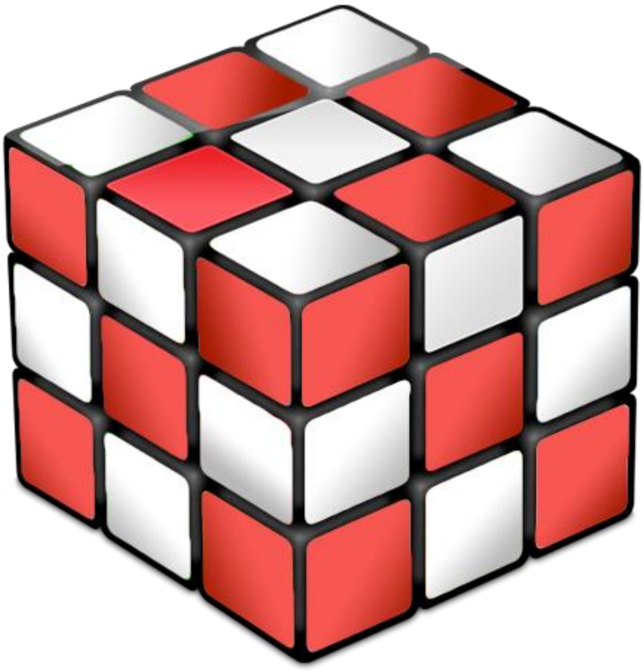
ADVACAM

API Python

- Devices
- Processing
- File formats



PIXET

Developer Documentation

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2. Introduction

The **PIXet** is a multi-platform software developed in ADVACAM company. It is a basic software that allows measurement control and saving of measured data with Medipix detectors. It supports Medipix2, Medipix3, Timepix and Timepix3 detectors and all the readout-devices sold by ADVACAM company such as FitPIX, AdvaPIX, WidePIX, etc. It is written in C++ language and uses multi-platform Qt libraries.

This document describes a python interface of the **PIXet** software. This interface consists of **pypixet.pyd** and **pypxproc.pyd**.

3. Requirements

3.1. Hardware

This API requires computer with x86 compatible architecture (no ARM, but can be on request), 64bit Windows or Linux and connected some Advacam hardware with imaging chip. Medipix3, Timepix, Timepix3, etc.

Some functions are universal for all hardwares (pypixet.start(), dev.doSimpleAcquisition(…), etc).
Some functions are not working with all (dev.setOperationMode(…) is not working with devices that has configurable individual pixels).
Some functions are specialized for only one chip type (dev.setColorMode(…) is Mpx3 only).

3.2. Software

The Pixet Python API can be used from the Python 2.7 interpreter integrated in the Pixet program or from commandline with external Python up to 3.x without the Pixet.

For starting from the Pixet Python scripting plugin are not need any special files.

If you want to run scripts without the Pixet, need additional files:
API functions using of **pypixet.pyd** and **pypxproc.pyd** and need **Python versions 2.7 to 3.x**, for Windows the Pixet core dlls: **pxcore.dll**, **pxproc.dll**, or linux **.so** ekvivalents. The library is **64bit only**.
The Pixet core need the **pixet.ini** file with proper hwlibs list inside, necessary hardware dll files (eq **minipix.dll**), subdirectory “**configs**” with config files for all present imaging chips (eq MiniPIX-I08-W0060.xml).

Pixet core on Windows need more Microsoft Visual Studio .NET standard dlls (vccorlib140.dll etc).

3.2.1. Required files – in more detail

3.2.1.1. The Pixet core, python and additional libraries:

pypixet.pyd (allways), **pypxproc.pyd** (clustering/spectral imaging)
pxcore.dll (allways), **pxproc.dll** (clustering/spectral imaging) or equivalent SO files on Linux

3.2.1.2. The **pixet.ini** file and the hwlibs

In the active directory must be the pixet.ini file. It must contains the [hwlibs] section with list of hwlib DLLs (or SOs) for devices that your project may supports. The hwlib files must be located in the locations specified in the pixet.ini. A semicolon at the beginning of a line disables the line.

Example1:

```
[Hwlibs]
hwlibs\minipix.dll
hwlibs\zest.dll
```

Example2:

```
[Hwlibs]
minipix.dll
zest.dll
;zem.dll
```

(Examples is for a Minipix and a Widepix with Ethernet)
Example1 is for hwlibs in the "hwlibs" subdirectory.
Example2 is for hwlibs with all files in the active directory and with Advapix disabled.

Hwlibs list:	Minipix:	minipix.dll
	Widepix with Eth:	zest.dll
	Widepix without Eth:	widepix.dll
	Advapix:	zem.dll

3.2.1.3. Additional files for some devices

Device INI files list:	Widepix with Eth:	zest.ini
	Widepix without Eth:	widepix.ini

Firmware images list:	Widepix-L:	zestwpx.bit
	Widepix-F:	zemwpxf.rbf
	Advapix-tpx3:	zemtpx3.rbf
	Advapix-tpx3-quad:	zemtpx3quad.rbf
	Advapix-Timepix:	zemtpx.rbf

3.2.1.4. The **factory** and the **configs** directories

The **factory** directory should contain the factory default configuration XML files. The Pixet core use it while starting, if the configuration file is not in the configs directory or program can use it by the **loadFactoryConfig()** method. This directory not need if the device has an internal config memory (Minipix for example).

The **configs** directory contain configuration XML files. The Pixet core try to use it while starting in **pypixet.start()** method and automatically save the current settings to it, if the **pypixet.exit()** method is used.

This process works the same way when you start and quit the Pixet program.

4. Overview of the Python API

The python API can be used:

- directly in the system console, using a general python interpret
- in the Pixet program integrated python console

The base is **pypixet object**. It has methods for initialize and deinitialize, can create the pixet object.
The **pixet object** have device list, can create device objects and allows access to global properties.
A **device objects** have methods for acquisions and allows access to device parameters.

The **pypxproc object** is intended for use to processing of a data.

The **pygui object** allows you to create your own graphical interface. It can be used only if a script is run from the Pixet program.

Small code example for using in the system console with the Python 3.7:

```
import pypixet

print("pixet core init...")
pypixet.start()
pixet=pypixet.pixet
devices = pixet.devicesByType(pixet.PX_DEVTYPE_TPX3)
dev = devices[0]
dev.setOperationMode(pixet.PX_TPX3_OPM_EVENT_ITOT)

print("dev.doSimpleAcquisition (3 frames @ 1 sec) - start")
rc = dev.doSimpleAcquisition(3, 1, pixet.PX_FTYPE_AUTODETECT, "example.png")
print("dev.doSimpleAcquisition - end:", rc, "(0 is OK)")

pixet.exitPixet()
```

Small code example for using in the Pixet python console with integrated Python 2.7:

```
# do not create the pypixet and pixet, they exist by default

devices = pixet.devicesByType(pixet.PX_DEVTYPE_TPX3)
dev = devices[0]
dev.setOperationMode(pixet.PX_TPX3_OPM_EVENT_ITOT)

print("dev.doSimpleAcquisition (3 frames @ 1 sec) - start")
rc = dev.doSimpleAcquisition(3, 1, pixet.PX_FTYPE_AUTODETECT, "example.png")
print("dev.doSimpleAcquisition - end: %d (0 is OK)" % rc)
# use the old-style print in the Pixet console ^^^

# do not execute the pixet.exitPixet(), it will cause whole the Pixet program to exit
```

5. The pypixet object

5.1. Using

start() Initialize the Pixet core.
If used from interpreter in the Pixet program, run next instance of Pixet.

Warning: If pypixet.start() was used, and then it was used again, the core cannot work properly. Various errors can occur later. Before repeat of the pypixet.start(), always must be used pypixet.exit()

Example: pypixet.start()

startgui() Initialize the Pixet core. Unlike the **start()** launches the graphical interface.

exit() Deinitialize the Pixet core. Save actual configuration to the default config file.
If used from interpreter in the Pixet program:

- and pypixet.start() was used, terminates both new and original Pixet instance.
- and pypixet.start() was not used, do nothing.

Example: pypixet.exit()

pixet The pixet object.

Example: pixet = pypixet.pixet

isrunning() Test when the Pixet core is running

Example: print("Pixet core running:", pypixet.isrunning())

pixetVersion() Return version of the Pixet.

6. The pixet object

The pixet object provide methods to manage connected devices, global configuration and system constants for many purposes.

6.1. Methods: General

exitPixet() Destroy data structures and correctly terminates all devices. Recommended before exiting the program, otherwise it may not work properly the next time you start and the device will need to be disconnect and connected. Save actual configuration to the default config file, if not exist.

registerEvent (eventName, reserved, callbackFun**)** Register event to use the callback function
unregisterEvent (eventName, reserved, callbackFun**)** Unregister event to stop using callback

eventName See Constants: Events
reserved Reserved to future use, now it doesn't matter the value or the type, recommend use 0.
callbackFun Name of the function that can be called by the event.

Note: Events on the pixet object are not widely used. They are more often used on devices. See Methods: Events

6.2. Methods: Devices management

devices() Array of all connected devices. If no devices connected, there is the virtual "FileDevice 0"
devicesByType(type) Array of all connected devices of desired type see Constants: Device type
devicesMpx2() Array of all connected Medipix2 devices
devicesMpx3() Array of all connected Medipix3 devices
devicesTpx3() Array of all connected Timepix3 devices
deviceCount() All connected devices count. If no devices connected, count is 1 (see **devices()**)
refreshDevices() Refresh devices list. It can be used after connect new device while prg. is running.

Example1:

```
devices = pixet.devices()
if devices[0].fullName()=="FileDevice 0":
    print("No devices connected")
    pixet.exitPixet()
    exit()

dev0 = devices[0]  # first of connected devices
```

Example2:

```
devices = pixet.devicesByType(pixet.PX_DEVTYPE_TPX3)
if len(devices)==0:
    print("No Tpx3 devices connected")
    pixet.exitPixet()
    exit()

dev0 = devices[0]  # first of connected Tpx3 devices
```

6.3. Methods: Directories informations

appDir()	Full path to the running program
appDataDir()	Full path to general data loading/saving
factoryDataDir()	Full path to the factory data – used by **dev.loadFactoryConfig()** method
logsDir()	Full path where logs are saved – created automatically at program start
configsDir()	Full path to configs loading/saving – created automatically at program start

Example:

```
pixet=pypixet.pixet
print("pixet.appDataDir", pixet.appDataDir())
print("pixet.appDir", pixet.appDir())
print("pixet.configsDir", pixet.configsDir())
print("pixet.factoryDataDir", pixet.factoryDataDir())
print("pixet.logsDir()", pixet.logsDir())
```

6.4. Constants: Device and chip types

These constants are a device type indexes and can be used for example:

```
# list of all connected Timepix3 devices
devices = pixet.devicesByType(pixet.PX_DEVTYPE_TPX3)
```

Sensor devices types list:

PX_DEVTYPE_MPX2
PX_DEVTYPE_MPX3
PX_DEVTYPE_TPX3
PX_DEVTYPE_TPX2
PX_DEVTYPE_MPX4
PX_DEVTYPE_TPX4

Special devices types list:

PX_DEVTYPE_DATADEV
PX_DEVTYPE_MOTOR
PX_DEVTYPE_XRAY
PX_DEVTYPE_AUX
PX_DEVTYPE_HVSOURCE

Chip types list:

PX_CHIPTYPE_MXR
PX_CHIPTYPE_TPX
PX_CHIPTYPE_MPX3
PX_CHIPTYPE_TPX3
PX_CHIPTYPE_TPX2
PX_CHIPTYPE_MPX4
PX_CHIPTYPE_TPX4

6.5. Constants: Operation modes

These constants are a device operation mode indexes. For various types of devices existing various sets of operation modes and constants sets. It can be used for example:

```
# set the Timepix3 operation mode "Time of arrival"
dev.setOperationMode(pixet.PX_TPX3_OPM_TOA)
```

Medipix3 OPM list:

PX_MPX3_OPM_SPM_1CH
PX_MPX3_OPM_SPM_2CH
PX_MPX3_OPM_CSM
PX_MPX3_OPM_SPM_1CH_COLOR**
PX_MPX3_OPM_SPM_2CH_COLOR**
PX_MPX3_OPM_CSM_COLOR**
PX_MPX3_OPM_CUSTOM

Timepix2 OPM list:

PX_TPX2_OPM_TOT10_TOA18
PX_TPX2_OPM_TOT14_TOA14
PX_TPX2_OPM_CONT_TOT10_CNT4
PX_TPX2_OPM_CONT_TOT14
PX_TPX2_OPM_CONT_TOA10
PX_TPX2_OPM_CONT_TOA14
PX_TPX2_OPM_CONT_CNT10
PX_TPX2_OPM_CONT_CNT14
PX_TPX2_OPM_ITOT10_TOA18
PX_TPX2_OPM_ITOT14_TOA14
PX_TPX2_OPM_CONT_ITOT10_CNT4
PX_TPX2_OPM_CONT_ITOT14

Timepix3 OPM list:

PX_TPX3_OPM_TOATOT
PX_TPX3_OPM_TOA
PX_TPX3_OPM_EVENT_ITOT
PX_TPX3_OPM_TOT_NOTOA

Timepix modes list: *

PX_TPXMODE_MEDIPIX
PX_TPXMODE_TOT
PX_TPXMODE_1HIT
PX_TPXMODE_TIMEPIX

OPMs summary:

TOA	Time of arrival
TOT	Time over threshold
EVENT	Event count
ITOT	Integrated time over threshold
CONT	Continuous mode
CNT	Count (=Event count)
SPM	Single pixel mode (=Event count)
CSM	Charge summing mode
MEDIPIX	(=Event count)
TIMEPIX	(=ToA)
1HIT	The Timepix OPM bits undocumented combination (experimental only)
COLOR**	Spectral imaging using coupled pixels with more thresholds

***Timepix (IMpx2)** modes
cannot be set by setOperationMode.
Use **pixcfg.setModeAll** or set the mode for each pixel.
See IMpx2TpxPixCfg operation modes management

****COLOR modes** working properly only with specially bonded chips with coupled pixels.

6.6. Constants: File types, extensions and flags

These constants are file types and extensions. It can be used for filenames testing or with acquisition methods.

Example:

```
# measure and save one 0.25 second frame to png file named "testFile.png"
dev.doSimpleAcquisition(1, 0.25, pixet.PX_FTYPE_PNG, "testFile")
dev.doSimpleAcquisition(1, 0.25, pixet.PX_FTYPE_AUTODETECT, "testFile.png")
```

File type constants	**File extensions constants**	
PX_FTYPE_NONE	(No direct file saving – data stored only in memory)	
PX_FTYPE_AUTODETECT	(FTYPE detected by extension in a filename)	
PX_FTYPE_ASCII_FRAME	PX_EXT_ASCII_FRAME	"txt"
PX_FTYPE_BINARY_FRAME	PX_EXT_BINARY_FRAME	"pbf"
PX_FTYPE_MULTI_FRAME	PX_EXT_MULTI_FRAME	"pmf"
PX_FTYPE_BINARY_MULTIFRAME	PX_EXT_BINARY_MULTI_FRAME	"bmf"
PX_FTYPE_TPX3_PIXELS	PX_EXT_TPX3_PIXELS	"t3p"
PX_FTYPE_TPX3_PIXELS_ASCII	PX_EXT_TPX3_PIXELS_ASCII	"t3pa"
PX_FTYPE_CLUSTER_LOG	PX_EXT_CLUSTER_LOG	"clog"
PX_FTYPE_PIXEL_LOG	PX_EXT_PIXEL_LOG	"plog"
PX_FTYPE_PNG	PX_EXT_PNG	"png"
PX_FTYPE_TPX3_RAW_DATA	PX_EXT_TPX3_RAW_DATA	"t3r"
PX_FTYPE_PIXET_RAW_DATA	PX_EXT_PIXET_RAW_DATA	"prd"
PX_FTYPE_EXTERNAL		
(description file saved automatically with pmf/txt)	PX_EXT_FRAME_DESC	"dsc"
(index file saved automatically with pmf/txt)	PX_EXT_INDEX	"idx"

txt ASCII matrix: Text files with img lines converted to text lines with numbers separated by spaces.
pbf Simple binary files, numbers only.
pmf Multiple frames. Default is same as the txt, but multiple frames on top of each other. Can use BINARY flag.
t3pa Tpx3 pixels ASCII. Text format, tab-separated columns with the header in the first row. Biggest to saving.
t3p Tpx3 pixels. Binary format. Lower saved size, more complex to understand.
t3r Tpx3 raw data. Fastest to saving, difficult to understand, slow to processing and can cause processing errors.
bstg Binary settings file: Measured data with all configuration (see Spectraimg methods and properties).
clog, plog Clusters/pixels logs. Text files contains clusters separated to frames with pixels lists. Historic formats for saving a data with few hited pixels in a frames.
h5 HDF5, hierarchical data format 5. Used as one of multi-frame formats.
info Text file with "[FileInfo]" head and all metadata list (see Frame metadata and his handling methods).
dsc Text file with frame index first and all metadata list (see Frame metadata and his handling methods).
idx Binary index for multi-frame files. Usesfull for fast access to n-th frame.

Frame file saving flags (Use in **save** or **doAdvancedAcquisition** methods. Flags can be combined.)
Deault is set of separate subframes text files, with all pixels include zeros, each subframe with idx+dsc files:
file_ToT.pmf, file_ToT.pmf.dsc, file_ToT.pmf.idx, file_ToA.pmf, file_ToA.pmf.dsc, file_ToA.pmf.idx

PX_FRAMESAVE_BINARY Use binary format in **pmf**.
PX_FRAMESAVE_SPARSEX Index + non-zero pixels in file. # separates (sub)frs.
PX_FRAMESAVE_SPARSEXY X, Y + non-zero pixel in file. # separates (sub)frames.
PX_FRAMESAVE_NODSC Do not add **dsc** file.
PX_FRAMESAVE_NOSUBFRAMES Do not use subframes, save main frame only.
PX_FRAMESAVE_SUBFRAMES_ONEFILE Save all subframes to a single file.
PX_FRAMESAVE_SUBFRAMES_SAVEMAINFRAME Save separate all subframes and main frame extra.

6.6.1. File extensions and flags: TXT/PBF/PMF details

Overview:

txt Single frame in the text file.
pbf Pixet Binary Frame - Single frame in the binary file.
pmf Pixet Multi Frame - Multiframe file with text or binary format, depends on flags used with saving.
idx Index for seeking - Binary array of 64b pointers to start of frames and subframes.
dsc Description. List of all metadata for each frame and subframe. Actual device and acquisition parameters, data types, etc. The "Frame name" item can be helpful to orientation in pmf structure if the ONEFILE flag used. The Type= item is helpful to understanding the structure of data if the BINARY flag used.

Note: All the next examples are for Timepix3, single chip, opm = pixet.PX_TPX3_OPM_TOATOT

Multi-files names generation:

flags 0 (default), input filename: “name”, acqCount = 1
name_ToA.txt, name_ToA.txt.dsc, name_ToT.txt, name_ToT.txt.dsc

acqCount = 6:
name_0_ToA.txt, name_0_ToA.txt.dsc, name_0_ToT.txt, …
…
name_5_ToA.txt, name_5_ToA.txt.dsc, …

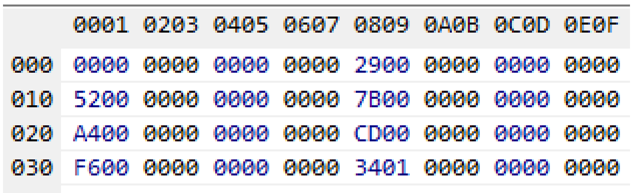
PMF note: With each pmf generating .pmf.idx binary file, other is same as TXT with acqCount = 1.

TXT file data, default:
0 0 0 5 0 0 0 … 256 numbers (int for non-calibrated values or float if the calibration used) and enter
0 872 0 0 0 … 256 numbers (int for non-calibrated values or float if the calibration used) and enter
(256 lines)

PMF file data, default:
0.00000 78.65742 0.00000 … 256 numbers (int for non-calibrated values or float if the calibration used) and enter
0.00000 0.00000 999785.5 … 256 numbers (int for non-calibrated values or float if the calibration used) and enter
(256 lines * acqCount)

The **PMF.IDX files** generated beside the PMFs. Contains the simple binary array of little-endian qword addresses of the each frame start.

.pmf.idx example:
Pointers to frames at 0, 0x29, 0x52, 0x7b, 0xA4, 0xCD, …



```
    0001 0203 0405 0607 0809 0A0B 0C0D 0E0F
000 0000 0000 0000 0000 2900 0000 0000 0000
010 5200 0000 0000 0000 7B00 0000 0000 0000
020 A400 0000 0000 0000 CD00 0000 0000 0000
030 F600 0000 0000 0000 3401 0000 0000 0000
```

TXT file data, pixet.PX_FRAMESAVE_SPARSEX flag:

```
_ToA.txt file: px index, ToA        _ToT.txt file: px index, ToT
------------------------------------------------------------------------
0       227212.500000               0       20
17      310685.937500               17      13
255     265487.500000               255     11
1274    105728.125000               1274    9
```

(lists of all hited pixels, int for non-calibrated data or float if the calibration used)

TXT file data, pixet.PX_FRAMESAVE_SPARSEXY flag:

```
_ToA.txt file: X, Y, ToA                      _ToT.txt file: X, Y, ToT
---------------------------------------------------------------------
247     3       189851.562500                 247     3       16
250     4       140042.187500                 250     4       12
5       9       317195.312500                 5       9       5
```

PMF file data, pixet.PX_FRAMESAVE_SPARSEX(Y) flag:
Same as TXT, but containing single lines with only # to separate frames:

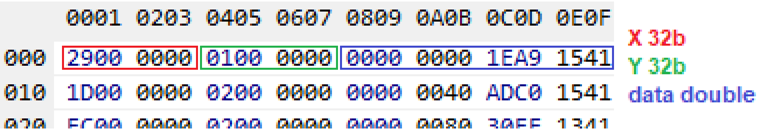
```
232     139     321620.312500
4       252     340231.250000
#
39      0       258270.312500
201     0       76593.750000
92      1       268642.187500
```

PX_FRAMESAVE_SUBFRAMES_ONEFILE:
All the data is in one file, subframes are placed one behind the other. If the measurement result have 10 frames with 2 subframes A/B, each _n TXT file contains 2 subrfames and the PMF contains 20 frames in order:
sfr0A, sfr0B, sfr1A, sfr1B, …
The exact order and names of type of (sub)frames is listed in the DSC file. The DSC have separate records [Fn] for all the items.

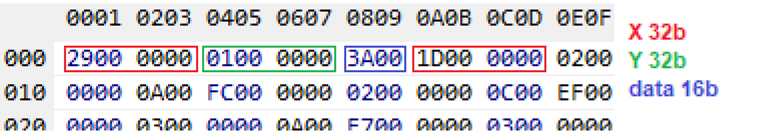
PX_FRAMESAVE_SUBFRAMES_SAVEMAINFRAME:
The group of the saved files contains the main frame and all subframes. Subframe files end in _sfrName, the main frame does not. In DSC file accompanying the TXT with main frame is not the "Frame name" item.
Not applicable if combined with the **ONEFILE** flag.

PX_FRAMESAVE_BINARY:
If the file type supports text and binary format, ex. PMF, save the binary.
Not applicable to TXT, must use PBF instead.
Data in the file are the simple array of non-calibrated 16 or 32b integers or calibrated doubles. See the DSC file for used data type.

BINARY + SPARSEXY examples:



```
     0001 0203 0405 0607 0809 0A0B 0C0D 0E0F
000  2900 0000 0100 0000 0000 0000 1EA9 1541
010  1D00 0000 0200 0000 0000 0040 ADC0 1541
020  FC00 0000 0200 0000 0000 0080 30FF 1341
```



```
     0001 0203 0405 0607 0809 0A0B 0C0D 0E0F
000  2900 0000 0100 0000 3A00 1D00 0000 0200
010  0000 0A00 FC00 0000 0200 0000 0C00 EF00
020  0000 0300 0000 0A00 F700 0000 0300 0000
```

6.6.2. File extensions and flags: DSC details

The first 3 lines have special functions:

1. File type selection
2. Index of the frame in this file
3. Arrangement and type of the data

Other lines are a list of metadata items separated by blank lines.
In txt.dsc and pbf.dsc, end of the frame is end of the file.
In the pmf.dsc, next item 2 and 3 and frame or subframe data follows.

Some example (PBF with BINARY and SPARSEXY – test_49_ToA.pbf.dsc):

B000000001	B=binary / A=ASCII and file type
[F0]	Index of frame in the file = 0
Type=double [X,Y,C] width=256 height=256	Pixel pos. X, Y and data with type double
"Acq Serie Index" ("Acquisition serie index"):	Some metadata item name and (description)
u32[1]	Type of the item data [number of values]
49	The value
(more metadata items separated by blank lines …)	
"Frame name" ("Frame name"):	
char[3]	
ToA	This is the ToA frame
(more metadata items separated by blank lines …)	
(end of the file)	

Other example (PMF with BINARY+SPARSEX+ONEFILE – test.pmf.dsc):

B000000010	
[F0]	Start of the first subframe
Type=double [X,C] width=256 height=256	Pixel index and double type pixel data (ToA in ns)
"Acq Serie Index" ("Acquisition serie index"):	
u32[1]	
0	
(more metadata items separated by blank lines …)	
"Frame name" ("Frame name"):	
char[3]	
ToA	
(more metadata items separated by blank lines …)	
[F1]	Start of the second subframe
Type=i16 [X,C] width=256 height=256	Pixel index and int16 pixel data (ToT counter value)
"Acq Serie Index" ("Acquisition serie index"):	
u32[1]	
0	

(and the ToT frame metadata, [F2] and ToA subframe, [F3] and ToT sfr, … [Fn] and ToT sfr of (n/2)th frame)

Complete one frame DSC example (BINARY+SPARSEX – test_15_ToA.pbf.dsc):

```
B000000001
[F0]
Type=double [X,C] width=256 height=256
"Acq Serie Index" ("Acquisition serie index"):
u32[1]
15

"Acq Serie Start time" ("Acquisition serie start time"):
double[1]
1639059034.903085

"Acq time" ("Acquisition time [s]"):
double[1]
0.500000

"ChipboardID" ("Chipboard ID"):
char[9]
I08-W0060

"DACs" ("DACs"):
u16[19]
16 8 128 10 120 1301 501 5 16 8 16 8 40 128 128 128 256 128 128

"Frame name" ("Frame name"):
char[3]
ToA

"HV" ("High voltage [V]"):
double[1]
-500

"Interface" ("Readout interface"):
char[7]
MiniPIX

"Mpx type" ("Medipix type (1-MXR, 2-TPX, 3-MPX3, 4-TPX3, 5-TPX2)"):
i32[1]
4

"Pixet version" ("Pixet version"):
char[5]
1.7.8

"Start time" ("Acquisition start time"):
double[1]
1639059042.934810

"Start time (string)" ("Acquisition start time (string)"):
char[64]
Thu Dec  9 15:10:42.934809 2021

"Threshold" ("Threshold [keV]"):
double[1]
5.026744
```

6.6.3. File extensions and flags: CLOG and CLOG.IDX details

The CLOG format was developed to facilitate further processing of cluster data by the user programs. This is a text file divided to the frame records and the records can contains a clusters. Frames and clusters are separated by the line breaks. Frames can be separated by whole free line.

The record format:
Frame FN (frameStart, frameAcqTime s)
[x, y, energy, ToA] [x, y, energy, ToA] [x, y, energy, ToA] …

FN Frame index number. First 0 or 1.
frameStart Start time of the frame. There are variants:
1. If it from measuring or from replay frame-based data with metadata available:
Linux format, frame starting time from PC’s getPrecisionTime.
2. If it from pixel-based data with metadata available (file.t3pa + file.t3pa.info):
Linux format, acq. starting time from PC’s getPrecisionTime with added time from data.
2. If it from replay data and metadata not available:
Nanoseconds from the input data.
Periodic increments if source is frame-based, random increments if source is data-driven.
frameAcqTime Duration of the frame, float in seconds. Always 0.000000 in data from data-driven sources.
x, y Position of the pixel.
energy* Energy deposited in the pixel. Integer ToT counter value if not calibrated, float in keV if calibrated.
ToA* Time of arrival, relative to frameStart. Integer in CLK ticks if ToA conversion is disabled,
float in ns if ToA conversion is enabled.

*ToA+energy records can be created from source that supports combined ToA+ToT modes, like as OPM_TOATOT on the Timepix3. If the data source supports only single modes, only one value is in this position.

Clog from data-driven source not contains free frames.
Clog from frame-based source can contains free frames.

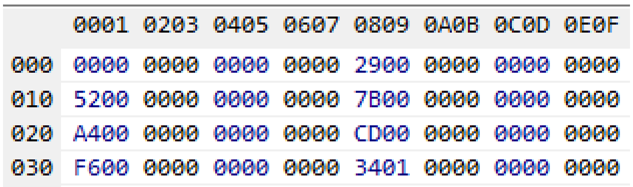
Example records (Timepix3, Frame2 with two clusters by 2 and 4 pixels, Frame3 with single 2-pixel cluster)
Frame 2 (273697060.937500, 0.000000 s)
[214, 195, 43.1598, 0] [220, 191, 20.6515, 7.8125]
[224, 182, 21.8018, 31.25] [223, 186, 4.58576, 31.25] [222, 183, 38.2381, 31.25] [226, 185, 14.7623, 34.375]

Frame 3 (371034565.625000, 0.000000 s)
[151, 33, 32.5745, 0] [151, 34, 13.8135, 17.1875]

Example records (Timepix)
Frame 6 (1639143482.765164, 0.200000 s)
[87, 134, 5.75352] [217, 58, 14.8396]
Frame 7 (1639143483.019154, 0.200000 s)
Frame 8 (1639143483.261158, 0.200000 s)
Frame 9 (1639143483.513150, 0.200000 s)

The **CLOG.IDX files** generated beside the CLOGs. Contains the simple binary array of little-endian qword addresses of the “F” at each record start.

.clog.idx example:
Pointers to records at 0, 0x29, 0x52, 0x7b, 0xA4, 0xCD, …



```
    0001 0203 0405 0607 0809 0A0B 0C0D 0E0F
000 0000 0000 0000 0000 2900 0000 0000 0000
010 5200 0000 0000 0000 7B00 0000 0000 0000
020 A400 0000 0000 0000 CD00 0000 0000 0000
030 F600 0000 0000 0000 3401 0000 0000 0000
```

6.6.1. File extensions and flags: T3PA details

The T3PA is timepix3 data file in text format with lines and tabs. Contains the information line and data lines with record index, pixel index, Time of arrival, Time over threshold, Fine ToA and Overflow. Example:

```
Index Matrix Index      ToA   ToT   FToA  Overflow
0     1028  1918  14    22    0
1     1028  3126  8     28    0
2     1028  3778  5     23    0
...
156003      39793 98473646054 38    9     0
156004      190   98492090610 19    3     0
```

The **Index** is simple index of measurement line. This growing while measurement is running. If you append new measurement to existing file, new index is 0 again and again growing while new measurement is running.

The **Matrix Index** is index of the pixel.
The **ToA** is time of arrival in units 25 ns.
The **ToT** is time over threshold in units 25 ns.
The **FToA** is “fine ToA” in units 16/25 ns to adds at ToA.

The **Overflow** is sign of data transfer overflow. If the line has this 1:
index = 0x74: start of lost data
index = 0x75: end of lost data, toa is length of the missing time
(this can occurs with rates over megahits per seconds for Minipix)

6.6.2. File extensions and flags: Pixel matrix configuration files

Overview:

bpc	**Binary Pixel Configuration**	All PM config in one file, meaning of the bits depends on the chip.
txt	**Ascii Mask Matrix**	Text file with pixel mask
txt	**Ascii Test Bit Matrix**	Text file with test bits
txt	**Ascii THL adj. bits Matrix**	Text file with threshold values adjustment

```
QString BPC = "Binary Pixel Configuration (*.bpc)";
QString ASCII_MASK = "Ascii Mask Matrix (*.txt)";
QString ASCII_TEST = "Ascii Test Bit Matrix (*.txt)";
QString ASCII_THL = "Ascii THL adj. bits Matrix (*.txt)";
```

6.7. Constants: Acquisition types and modes, incl. triggers

These constants can be used with the **doAdvancedAcquisition** method, for example:

```
# acquisition for 2 seconds in data-driven mode
# without special trigering features, store data in the memory
dev.doAdvancedAcquisition(1, 2, pixet.PX_ACQTYPE_DATADRIVEN,
                               pixet.PX_ACQMODE_NORMAL, pixet.PX_FTYPE_NONE, 0, "")
```

Acquisition types:	**Acquisition modes:**	**Modes description:**
PX_ACQTYPE_FRAMES	PX_ACQMODE_NORMAL	Start immediately on doAcq... method
PX_ACQTYPE_TESTPULSES	PX_ACQMODE_TRG_NO	Start immediately on doAcq... method
PX_ACQTYPE_DATADRIVEN	PX_ACQMODE_TRG_HWSTART	Start on trig HW signal edge
	PX_ACQMODE_TRG_HWSTOP	Stop on trig HW signal edge
	PX_ACQMODE_TRG_HWSTARTSTOP	Start and stop on trig HW signal edge
	PX_ACQMODE_TRG_SWSTART	Start on software trigger
	PX_ACQMODE_COMPRESSED	Save compressed stream
	PX_ACQMODE_TDI	Time delayed integration mode
	PX_ACQMODE_CONTINUOUS	Continuous mode: Repeat acqs until abort

6.8. Constants: Frame types

Frames from frame acq.

PX_FRAMETYPE_I16
PX_FRAMETYPE_U32
PX_FRAMETYPE_DOUBLE
PX_FRAMETYPE_U64

Frames from pixels preview

PX_TPX3_FRAMETYPE_SUM
PX_TPX3_FRAMETYPE_FADE

6.9. Constants: Events

These constants can be used to register, use in callbacks and unregister various events. Example:

```
# register event "Acq finished" to use function "callbackFin"
dev.registerEvent(pixet.PX_EVENT_ACQ_FINISHED, 0, callbackFin)
```

Events used in acquisitions:

PX_EVENT_ACQ_MEAS_STARTED	Measurement was started (0 if start OK / error code)
PX_EVENT_ACQ_MEAS_FINISHED	Measurement was finished (0 if success / error code)
PX_EVENT_ACQ_SERIE_STARTED	Series of acquisitions was started (count of finished series =0)
PX_EVENT_ACQ_SERIE_FINISHED	Series of acquisitions was finished (count of finished series =1)
PX_EVENT_ACQ_FINISHED	One acquisition was finished (count of finished acqs) *(frame mode)*
PX_EVENT_ACQ_NEW_DATA	New data arrival (actual acq index) *(data-driven mode)*
PX_EVENT_ACQ_ABORTING	Aborting of acquisition is in progress
PX_EVENT_ACQ_ABORTED	Acquisition was aborted
PX_EVENT_ACQ_FAILED	Acquisition was failed (error code from the Pixet core)
PX_EVENT_ACQ_SWTRG_READY	Software trigger is ready

Typical order of events in the measurement process:
0. start of execution of a method like as do…Acquisition
1. ACQ_MEAS_STARTED (0)
2. ACQ_SERIE_STARTED (0)
3. DEV_STATUS_CHANGED (0)
4f. ACQ_FINISHED (1), ACQ_FINISHED (2), ACQ_FINISHED (3), … (frame mode)
4d. ACQ_NEW_DATA (0), ACQ_NEW_DATA (0), ACQ_NEW_DATA (0), … (data-driven mode)
5. ACQ_FINISHED (all frames count in frames / 1 in data-driven)
6. ACQ_SERIE_FINISHED (1)
7. ACQ_MEAS_FINISHED (0)
8. execution of acquisition method ends (if doContinuousConversion was used, this happened between 1 and 2)

Other envents list:

PX_EVENT_DEV_CFG_CHANGED
PX_EVENT_DACS_CHANGED
PX_EVENT_BIAS_CHANGED
PX_EVENT_CFG_SAVING_PROGRESS
PX_EVENT_CFG_LOADING_PROGRESS

PX_EVENT_PIXCFG_CHANGED
PX_EVENT_TPXCLOCK_CHANGED
PX_EVENT_MPX3OPM_CHANGED
PX_EVENT_TPX3STG_CHANGED

PX_EVENT_LOCK_CHANGED
PX_EVENT_DEV_MENU_CHANGED
PX_EVENT_DEV_STATUS_CHANGED

PX_EVENT_MENU_CHANGED
PX_EVENT_NEW_DEVICE
PX_EVENT_DEVICE_REMOVED
PX_EVENT_FILTERS_CHANGED
PX_EVENT_EXIT

PX_EVENT_TPX2CLOCKS_CHANGED
PX_EVENT_TPX2STG_CHANGED
PX_EVENT_MOTOR_STATUS_CHANGED

6.10. Constants: Data formats

```
PX_DATAFORMAT_NONE
PX_DATAFORMAT_FRAME
PX_DATAFORMAT_COMP_STREAM
PX_DATAFORMAT_TPX3_PIXELS
PX_DATAFORMAT_TPX_PIXELS
PX_DATAFORMAT_MULTIFRAME
PX_DATAFORMAT_TPX3_CLUSTERS
PX_DATAFORMAT_EXTERNAL
```

6.11. Constants: Threshold values

PX_THLFLG_NONE	Raw DAC value.
PX_THLFLG_RELATIVE	Relative THL for more chips. Ref can be set by SET_RELATIVE.
PX_THLFLG_ENERGY	Absolute THL value in keV.
PX_THLFLG_RELATIVE_CURRENT	Relative THL to current value. Usesfull to increments etc.
PX_THLFLG_SET_RELATIVE	Only set the reference THL value for RELATIVE.

6.12. Constants: Pixels matrix config types

See The pixels matrix configuration objects

```
PX_PIXCFG_MXR
PX_PIXCFG_TPX
PX_PIXCFG_MPX3
PX_PIXCFG_TPX3
PX_PIXCFG_TPX2
PX_PIXCFG_ALL
PX_PIXCFG_MASK
PX_PIXCFG_TEST
PX_PIXCFG_THL
PX_PIXCFG_THH
PX_PIXCFG_TPXMODE
PX_PIXCFG_GAIN
```

6.13. Constants: Other

PX_CHIP_ALL	Chip index for indexing all the device chips. Applicable to setDac, setThreshold, ...

6.14. Similar related to previous lists

There is not pixet constants, but it is similar lists.

6.14.1.1. Data types

This is the numbers used to determine the datatype of the value. This can be copied to the user code.

```
DT_CHAR     = 0          DT_FLOAT    = 8
DT_BYTE     = 1          DT_DOUBLE   = 9
DT_I16      = 2          DT_BOOL     = 10
DT_U16      = 3          DT_STRING   = 11
DT_I32      = 4
DT_U32      = 5
DT_I64      = 6
DT_U64      = 7
```

6.14.1.2. Named parameters

Devices have named parameters. See Parameters names lists by device types

6.14.1.3. Error codes list

```
#define PXERR_NO_ERROR                (     0)
#define PXERR_FRAME_NOT_FOUND         ( -1000)
#define PXERR_EVENT_EXIST             ( -1001)
#define PXERR_EVENT_NOEXIST           ( -1002)
#define PXERR_EVENT_FUNC_NOEXIST      ( -1003)
#define PXERR_BUFFER_SMALL            ( -1004)
#define PXERR_INVALID_ARGUMENT        ( -1005)
#define PXERR_FRAME_EMPTY             ( -1006)
#define PXERR_ABORTED                 ( -1007)
#define PXERR_ACQ_FAILED              ( -1008)
#define PXERR_READ_DATA_FAILED        ( -1009)
#define PXERR_FILE_OPEN               ( -1010)
#define PXERR_FILE_READ               ( -1011)
#define PXERR_FILE_WRITE              ( -1012)
#define PXERR_FILE_BADDATA            ( -1013)
#define PXERR_FILE_SEEK               ( -1014)
#define PXERR_MEMORY_ALLOC            ( -1015)
#define PXERR_ITEM_NOT_FOUND          ( -1016)
#define PXERR_INVALID_DATA_TYPE       ( -1017)
#define PXERR_UNEXPECTED              ( -1018)
#define PXERR_FRAME_LOCKED            ( -1019)
#define PXERR_PLUGIN_EXISTS           ( -1020)
#define PXERR_PLUGIN_INITERROR        ( -1021)
#define PXERR_MENUITEM_EXISTS         ( -1022)
#define PXERR_CANNOT_CONVERT          ( -1023)
```

```
#define PXERR_LOCK_TIMEOUT       ( -1024)
#define PXERR_NOT_LOCK_OWNER     ( -1025)
#define PXERR_UNSUPPORTED        ( -1026)
#define PXERR_NOT_FOUND          ( -1027)
#define PXERR_EXISTS             ( -1028)
#define PXERR_REFCOUNT_NONZERO   ( -1029)
#define PXERR_DEVICE_ERROR       ( -1030)
#define PXERR_NO_ITEMS           ( -1031)
#define PXERR_NO_MORE_ITEMS      ( -1032)
#define PXERR_INVALID_FILE_TYPE  ( -1033)
#define PXERR_AUTODETECT_FAILED  ( -1034)
#define PXERR_BUFFER_FULL        ( -1035)
#define PXERR_ACQ_RUNNING        ( -1036)
#define PXERR_TEMPERATURE_ERROR  ( -1037)
#define PXERR_INVALID_DATA       ( -1038)

#define PXERR_ACQFAIL_ERRORS_START          ( -5000)
#define PXERR_ACQFAIL_COMMUNICATION         ( -5001)
#define PXERR_ACQFAIL_TEMPERATURE_ERROR     ( -5002)
#define PXERR_ACQFAIL_SAVING_DATA           ( -5003)
#define PXERR_ACQFAIL_ERRORS_END            ( -5999)
```

6.14.1.4. Spectraimg constants and error codes

See Spectraimg constants and error codes

7. Sensor device objects

Objects in this chapter: **IDevTpx3** (Timepix3)**, IDevMpx2** (Medipix2, Timepix)**, IDevMpx3** (Medipix3).

This chapter is **by default about the IDevTpx3**. See notes for other devices.

Example:

```
pixet=pypixet.pixet
dev = pixet.devices()[0]
```

The dev is IDevTpx3 object created by pixet's device() method or other his device…() methods if connected device with index 0 have the Timepix3 chip.

7.1. Methods: Device info

deviceType()	Returns type of the device (see Constants: Device types)
fullName()	Returns full name of the device. Example print: MiniPIX I08-W0060
deviceID()	Returns device ID. This is same as first chip serial number. Example print: I08-W0060
chipIDs()	Returns array of all installed chip IDs. Example print: ['I08-W0060']
chipIDSummary()	Returns chip ID summary. This is same as first chip serial number. Example: I08-W0060
hasDefaultConfig()	Returns 1 if device has default config or 0 if not
supportedAcqModes()	Returns OR of all acq. modes (see Constants: Acquisition types and modes, incl. triggers)
supportedAcqTypes()	Returns OR of all acq. types (see Constants: Acquisition types and modes, incl. triggers)
acqTimeMin()	Returns shortest allowed acquisition time in seconds
acqTimeMax()	Returns longest allowed acquisition time in seconds
sensorThickness()	Returns sensor chip thickness in micrometers
sensorPitch(idx**)**	Returns pixels pitch in micrometers of the indexed chip
sensorType(idx**)**	Returns sensor type string of the indexed chip. Example print: CdTe
width()	Returns width of the sensor in pixels
height()	Returns height of the sensor in pixels
pixelCount()	Returns count of pixels in the sensor (width*height)
chipType()	Returns index of chip type (see Constants: Device and chip types)
chipCount()	Returns number of sensor chips in the device
isPolarityPositive(idx**)**	Returns 1 if polarity of the bias voltage on indexed chip is positive or 0 if not
adcCount()	Returns count of ADCs available in the device
adcValue(idx**)**	Returns value from indexed ADC
isConfigInDeviceSupported()	Returns 1 if store of configuration data in the device is supported or 0 if not
hasConfigInDevice()	Returns 1 if configuration data are stored in the device
hasDefaultConfig()	Returns 1 if the pixCfg have 0 in all maskBit, testBit and thl items, or 0 if not. This means, if 1 returned, the device has no config (but 0 not means proper config).

7.2. Methods: General

operationMode() Returns actual device operation mode * (see Constants: Operation modes)
setOperationMode(opm**)** Sets the device operation mode * (see Constants: Operation modes)
* If device haven't this, use pixcfg.**setModeAll**. (see The pixels matrix configuration objects)

lastError() Returns last error msg. (useful with return codes testing or ACQ_FAILED callback)
deviceStatusText() Returns device status text

defaultConfigFileName() Returns default full path for device config file
loadConfigFromFile(path**)** Loads config from the specified file
saveConfigToFile(path**)** Saves actual config to the specified file
loadConfigFromDevice() Loads config stored in the device
saveConfigToDevice() Stores actual config in the device (**use only with certainty of the correct config**)
loadFactoryConfig() Loads factory default config from the "factory" directory.
isConnected() Returns 1 if device is connected or 0 if not
reconnect() Reinitializes the device, same as plug/unplug the cable
isBusy() Returns 1 if device is busy or 0 if not
isDeviceLocked() Returns 1 if device is locked or 0 if not
lockDevice() Sets device as locked
unlockDevice(bool force**)** Sets device as unlocked. Use force=true to force unlock.
enableInterpolationOfMaskedPixels(bool enable, flags**)** Enables/disables interpolation of masked pixels.
Use flags 0 or **PX_INTERPOL_FLAG_BAD_COLUMNS** to enable interp. of columns.
isInterpolationOfMaskedPixelsEnabled() Returns 1 if interpolation of masked pixels is enabled or 0 if not.
setConvertToaTime(bool convert**)** If enabled, in ToA subframes will be counter and fine counter converted to the nanosecs, if not, two separate subframes will be created:

1. ToA named, with ToA counter raw values
2. FTOA named, with fine ToA counter raw values

(see Frame access and related methods)

isConvertToaTimeEnabled() Returns 1 if ToA convert is enabled or 0 if not.
setCalibrationDataAbct(chipIdx, dataa, datab, datac, datat**)** Associates calibration arrays to indexed chip.
calibrationDataAbct(chipIdx, dataa, datab, datac, datat**)** Reads calibration data of indexed chip to the arrays.
useCalibration(bool enable**)** Enable/disable ToT calibration (convert to energy) of a data in frame mode.
isUsingCalibration() Returns 1 if calibration of a frame data is enabled or 0 if not.
hasCalibration() Returns 1 if device has calibration (default after manuf. expedition) or 0 if not.
calibrateFrame(frame**)** Apply calibration to the frame.

pixCfg() Returns the pixel matrix config object (see The pixels matrix configuration objects)
createCopyOfPixCfg() Returns copy of the pixel matrix object. Usesfull to backup the pixCfg settings.
refreshPixelCfg() Sets the pixel matrix configuration from the pixCfg memory to the device.
setPixCfg(pixcfg**)** Sets the pixel matrix configuration from the used pixCfg object to the device.

parameters() Returns the IParamMgr object (see Accessing the named parameters)
asIDev() Returns the IDev object. This can be used to connect the device to other objects, pypxproc for example (see The pypxproc object).

7.3. Methods: Acquisition and related

7.3.1. The acquisition

doSimpleAcquisition(count, time, fileType, fileName**)** Acquire desired number of frames in normal/frame mode, to be used each separately.

doSimpleIntegralAcquisition(count, time, fileType, fileName**)** Acquire desired number of frames in normal/frame mode and integrate all to single frame.

doAdvancedAcquisition(count, time, acqType, acqMode, fileType, fileFlags, fileName**)**
Frame mode: Acquire desired number of frames to be used each separately.
Data-driven mode: Acquire pixels for desired time.
Support acq. type and mode set.

doAdvancedIntegralAcquisition(count, time, acqType, acqMode, fileType, fileFlags, fileName**)**

count	Number of acquisitions to do (in data-driven mode exact value ignored, only must be over 0)
time	Each acquisition time [sec]
fileType	Type of file to be saved, or pixet.PX_FTYPE_NONE to store data in memory
fileName	Filename if files used or “” if not. See Constants: File types, extensions and flags
fileFlags	Flags for file saving. See Constants: File types, extensions and flags
acqType	Acquisition type (frames / test pulses / data-driven)
acqMode	Acquisition mode (normal / triggered / …) See Constants: Acquisition types and modes, incl. triggers

The above methods start the measurement and wait for it’s end. If file specified, this save single or more files. Depends on operation mode, more files can be created from each acquisition.

Example:

```
import pypixet

print("pixet core init...")
pypixet.start()
pixet=pypixet.pixet
devices = pixet.devicesByType(pixet.PX_DEVTYPE_TPX3)
dev = devices[0]
dev.setOperationMode(pixet.PX_TPX3_OPM_EVENT_ITOT)

print("dev.doSimpleAcquisition (2 frames per 1 sec) - start")
rc = dev.doSimpleAcquisition(2, 1, pixet.PX_FTYPE_AUTODETECT, "test.png")
print("dev.doSimpleAcquisition - end:", rc)

pixet.exitPixet()
```

This example save files: test_0_Event.png, test_0_iToT.png, test_1_Event.png, test_1_iToT.png

If filename “” specified, or fileType NONE, data is stored only in memory. After each acquisition, data can be read via **lastAcqFrameRefInc()** in frame mode, or via **lastAcqPixelsRefInc()** in data-driven mode. This can be used after end, if count is 1, or via callbacks. Event **ACQ_FINISHED** in frame mode or **ACQ_NEW_DATA** data-driven mode.

To use events with callback, must use **registerEvent** device method before start of measurement. After process ends, can be used **unregisterEvent** to stop this (see Methods: Events). Even more events can be used in connection with the measurement (see details in Constants: Events).

Example:

```
# first is same code as in the previous example, up to dev.setOperat...
def clbACQ_FINISHED(cnt):
    print("ACQ_FINISHED", cnt)
    frame = dev.lastAcqFrameRefInc()
    data = frame.data()
    print("  Px val min:", min(data), ", max:", max(data))
    frame.destroy()

dev.registerEvent(pixet.PX_EVENT_ACQ_FINISHED, 0, clbACQ_FINISHED)

print("dev.doSimpleAcquisition (5 frames per 1 sec) - start")
rc = dev.doSimpleAcquisition(5, 1, pixet.PX_FTYPE_NONE, "")
print("dev.doSimpleAcquisition - end:", rc)
```

This example acquires 5 frames and display minimum and maximum pixel value from each frame.
Note: Most device types have subframes and frame.data() contains only processing artefacts. See Frame access and related methods and Frame with subframes example

doContinuousAcquisition(buffCount, time, acqMode**)**

buffCount Number of buffers. After number of acquired frames reach buffCount, event DEV_STATUS_CHANGED occurs, frame count resets and start overwriting of previous frames stored in the memory.

This method is “callbacks-only”. Unlike the previously described methods, this terminates immediately after the "ACQ_MEAS_STARTED" event. The process continues to run in the background and generating callbacks. In this time, program can do anything else or simply waiting, like as input(“Press enter to end”).

Warning: Currently, **this feature is somewhat experimental**. For some devices, the acqMode parameter value has no effect. For future compatibility use the pixet.PX_ACQMODE_CONTINUOUS. On Tpx3 abort not working and this process cannot be terminated correctly.

isAcquisitionRunning()	Returns 1 if acq. is now running or 0 if not
isAcquisitionAborting()	Returns 1 if now aborting of a acq. or 0 if not
abortOperation()	Aborts a running operation. Can be used to stop the ContinuousAcquisition.

7.3.2. Software trigger

isReadyForSoftwareTrigger()	Returns 1 if device is ready to start acq. by the software trigger or 0 if not
doSoftwareTrigger(flags**)**	Do the the software trigger now. Flags is reserved for future use, recommended 0

This can be used in acquisition mode **PX_ACQMODE_TRG_SWSTART** (other TRG_SW… modes are reserved for future use). See Constants: Acquisition types and modes, incl. triggers

After use start acquisition method in this mode, event occurs **PX_EVENT_ACQ_SWTRG_READY** and sw. trigger is ready. From this time, acquisition starts immediately with dev.**doSoftwareTrigger** used. Note: "immediately" in Python, understand with exaggeration.

7.3.3. Online data processing, events and callbacks

Online data processing is possible by two ways:

A) Do acquisition(s) without files and process the data after it ends

B) Do acquisition(s) without files and process the data in callback functions while acq. running
   - In frame mode, the **PX_EVENT_ACQ_FINISHED** occurs after each frame.
   - In data-driven mode, the **PX_EVENT_ACQ_NEW_DATA** occurs after some pixels arrival. Maximum event rate is approximately twice per second. Maximum pixel rate is about 1.4 million pixels per event, depending on the speed of the computer, condition of the data path and other circumstances.

acqDataCount()	Returns number of data blocks waiting in memory (data-driven mode)
acqFrameCount()	Returns number of frames waiting in memory (frame mode)
acqFrameRefInc(idx**)**	Get the frame object from indexed acquisition (see The frame object)
lastAcqFrameRefInc()	Get the frame object from last acquisition (see The frame object)
lastAcqPixelsRefInc()	Get the pixels object from last acquisition (see The pixels object)

7.3.4. Events: more details

registerEvent (eventName, reserved, callbackFun**)**	Register general event to use the callback function
unregisterEvent (eventName, reserved, callbackFun**)**	Unregister general event to stop using callback

eventName	See Constants: Events
reserved	Reserved to future use, now it doesn't matter the value or the type, recommend use 0.
callbackFun	Name of the function that can be called by the event.

registerBeforeSaveDataEvent (reserved, callbackFun**)**
unregisterBeforeSaveDataEvent (reserved, callbackFun**)**

Register/unregister the “before save” event to use (stop using) callbackFun. This is special event, which occurs while measurements with file-saving is running, before start saving each file. Parameter of callback function is frame object with data to be saved. It can be used for add attributes or preprocessing. In data-driven mode, this event occurs very often. Be carefully for CPU load if use it.

7.4. Methods: Special

7.4.1. Sensor refresh

The sensor refresh is used to clean the sensor of free charges. Process containing sequence of bias changes.

isSensorRefreshSupported() Returns 1 if the device support sensor refresh process or 0 if not.
isSensorRefreshEnabled() Returns 1 if the sensor refresh process enabled on the device or 0 if not.
enableSensorRefresh(en, time**)** Enable/disable automatic sensor refresh.
time: 0 = refresh before every meas. start / >0 refresh every time seconds.
doSensorRefresh() Do the sensor refresh now.

sensorRefreshString(string**)** Sets the sensor refresh sequence text. Suitable values depend on chip manufacturing technology details.
The refresh string defines steps with pairs of times [sec] and bias coefficients [1=100%] (physical bias values limited to min/max chip properties)

Example:

```
# ("time1, coef1; time2, coef2; time3, coef3; ...")
dev.sensorRefreshString("5, 2; 3, 1.5; 1, 1.2; 1, 1")
```

7.4.2. Threshold settings

threshold(ch, flags**)** Returns the threshold value from indexed chip (flags: see Constants: Threshold values)
setThreshold(ch, val, flags**)** Set the threshold value on indexed chip (flags: see Constants: Threshold values)

Note: Some device types have individual pixel thresholds. See Thresholds management

7.4.3. Bias settings

bias() Returns actual bias set value.
biasMin() Returns minimal allowed bias value.
biasMax() Returns maximal allowed bias value.
setBias(voltage**)** Sets the bias voltage.

IsBiasSenseSupported() Returns 1 if device support bias sensing or 0 if not.
biasVoltageSense() Returns actual measured bias voltage in V.
biasCurrentSense() Returns actual measured bias current in µA.

7.4.4. Digital test

doDigitalTest() Do the digital test. Writes the test data to the device, read and verify. Returns return code, good pixels count, bad pixels count and frame with it's map (1 bad / 0 good).

Example:

```
rc, good, bad, frame = doDigitalTest()
if rc==0:
      print("good pixels", good, "bad pixels", bad)
else:
      print("Digital test failed")
```

7.4.5. DACs control

Many sensor devices contain digital-to-analog converters. These are used to set some internally used voltages and currents. Refer to the device/chip datasheets for details on their meaning.

Warning: This is very low-level thing, direct driving of DACs is not needed for normal device using. Using the wrong settings can lead to strange behaviour, sometimes even damaging the device.

dacs() Returns the IMpxDacs object to control the devices DACs. See The IMpxDacs object
createCopyOfDacs() Returns the IMpxDacs object to store all the device DACs settings.
setDacs(dacs**)** Sets all the device DACs settings by used IMpxDacs object.
refreshDacs() Sets all the device DACs settings to the DACs outputs.

7.5. The IDevMpx3 object (differences from IDevTpx3)

The Medipix3 sensor is very specific. It have large amount of settings.

resetMedipix()
setMinThresholdNoise(int chip, int thlIndex, double thresholdKev)
isThresholdCalibrated
setThresholdCalibCoeffs(int chip, int thlIndex, int gainMode, int bitDepth, double* calibParams, size_t size)
thresholdCalibCoeffs(int chip, int thlIndex, int gainMode, int bitDepth, double* calibParams, size_t size)
thresholdCalibCoeffNamesList(IStrList* list)
thresholdCalibCoeffNames()
isColorModeSupported()
isColorModeEnabled()
setColorMode(bool enabled)
isChargeSummingEnabled()
setChargeSumming(bool enabled)
isContinuousReadWriteEnabled()
setContinuousReadWrite(bool enabled)
counterDepth()
setCounterDepth(byte depth)
selectedCounter()
setSelectCounter(byte counter)
columnBlock()
setColumnBlock(byte columnBlock)
rowBlock()
setRowBlock(byte rowBlock)
isEqualizeEnabled()
setEqualize(bool enabled)
isDiscCsmSpmEnabled()
setDiscCsmSpm(bool enabled)
alias
dacsMode(int opMode)
setDacsMode(int opMode, const IMpxDacs* dacs)
createCopyOfDacsMode(int opMode)
pixCfgMode(int opMode)
createCopyOfPixCfgMode(int opMode)
setPixCfgMode(int opMode, const IMpxPixCfg* pixCfg)

setPixCfg(pixCfg)

gain() Returns the active gain option of the charge convertor.
setGain(gain**)** Sets the gain option. Use pixet.PX_MPX3_GAIN… constants.

PX_MPX3_GAIN_SUPERHIGH	alias	PX_MPX3_GAIN_SUPER_NARROW
PX_MPX3_GAIN_HIGH	alias	PX_MPX3_GAIN_NARROW
PX_MPX3_GAIN_LOW		
PX_MPX3_GAIN_SUPERLOW	alias	PX_MPX3_GAIN_BROAD

PX_EVENT_MPX3OPM_CHANGED

7 Sensor device objects

8. Other device objects

PX_DEVTYPE_MPX2+
PX_DEVTYPE_MPX3+
PX_DEVTYPE_TPX3+
PX_DEVTYPE_TPX2
PX_DEVTYPE_MPX4
PX_DEVTYPE_TPX4
PX_DEVTYPE_DATADEV
PX_DEVTYPE_MOTOR
PX_DEVTYPE_XRAY
PX_DEVTYPE_AUX
PX_DEVTYPE_HVSOURCE

9. Accessing the named parameters

The counter-based imaging devices have large amount of parameters and majority of them have not own separate set/get method. In addition, many such parameters are specific to different types of devices. Solution is text named parameters. The device parameter objects are intended for manipulate with the named parameters. Many of this parameters are read-only from the device (TemperatureCpu) therefore it is widely named “readout parameters”. But also existing writable (TrgStg) or named parameters of the system (DDBlockSize).

Example:

```
pars = dev.parameters()
print("CPU Temp:", pars.get("TemperatureCpu").getDouble(), end='')
print(", Chip Temp:", pars.get("TemperatureChip").getDouble())
```

9.1. The IParamMgr object and his methods

This is the interface to access IParam, named parameters objects in the device.

count() Returns number of named parameters of the device.
params() Get array of the the IParam objects.
hasParam(name**)** Returns 1 if the device has a parameter with the name or 0 if not.
get(name**)** Get single IParam object with the name.

9.2. The IParam object and his methods

This is object containing name, description, flags and the parameter value.

name() Returns text name of the data in the object.
byteSize() Returns size of data in bytes.
description() Returns description text for data.
flags() Returns flags of the data.
setFlags() Set flags of the data.
type() Returns index of type of the data (see Data types).

getBOOL, getByte, getChar, getDouble, getFloat, getI16, getI32, getI64, getU16, getU32, getU64, getString

Returns value of the data. Works properly only if the correct data type is used.

setBOOL, setByte, setChar, setDouble, setFloat, setI16, setI32, setI64, setU16, setU32, setU64, setString

Set the data value. Works properly only if the correct data type is used.
Note: Majority of a named parameters are read only.

9.3. Parameters names lists by device types

These are lists collected form the Pixet C++ source code. Use the strings. Names and notes can sometimes be helpful.

9.3.1. Tpx3 parameter names list

```
#define PAR_LIBVER              "HwLibVer"
#define PAR_DEBUGLOG            "DebugLog"
#define PAR_DUMMYACQ            "DummyAcqNegativePolarity"
#define PAR_TEMP                "Temperature"
#define PAR_TEMP_CHIP           "TemperatureChip"
#define PAR_TEMP_CPU            "TemperatureCpu" // mimipix/tpx3 only
#define PAR_TEMP_CHIP_CPU       "TemperatureChipCpu" // mimipix/tpx3 only
#define PAR_TEMP_READ_ACQSERIE  "TemperatureReadBeforeAcqSerie" // mimipix/tpx3 only
#define PAR_TEMP_READ_EVERYACQ  "TemperatureReadBeforeEachAcq" // mimipix/tpx3 only
#define PAR_TEMP_CHECK_IN_SW    "CheckMaxTempInSW" // mimipix/tpx3 only
#define PAR_TEMP_CHECK_IN_CPU   "CheckMaxChipTempInCPU" // mimipix/tpx3 only
#define PAR_TEMP_MAX_ALLOWED_TEMP   "MaxAllowedChipTemp" // mimipix/tpx3 only
#define PAR_DAC_BANGAP          "DacBandGap"
#define PAR_DAC_TEMP            "DacTemp"
#define PAR_BIAS_SENSE_VOLT     "BiasSenseVoltage"
#define PAR_BIAS_SENSE_CURR     "BiasSenseCurrent"
#define PAR_DD_BUFF_SIZE        "DDBuffSize"
#define PAR_DD_BLOCK_SIZE       "DDBlockSize"
#define META_SHUTTER_TIME       "Shutter open time" // mimipix/tpx3 only
#define PAR_CHAN_MASK           "ChanMask" // no net/tpx3
#define PAR_READOUT_CLOCK       "ReadoutClock" // no net/tpx3
#define PAR_TRG_STG             "TrgStg"
#define PAR_TRG_TIMESTAMP       "TrgTimestamp"
#define PAR_TRG_T0SYNC_RESET    "TrgT0SyncReset"
#define PAR_TRG_READY           "TrgReady"  // no net/tpx3
#define PAR_TRG_OUTLEVEL        "TrgOutLevel" // mimipix/tpx3 only
#define PAR_TRG_OUT_ENABLE      "TrgOutEnable" // mimipix/tpx3 only
#define PAR_TRG_IS_MASTER       "IsMaster"
#define PAR_MOTOHOURS           "Motohours"  // mimipix/tpx3 only
#define PAR_MTX                 "MTX" // mimipix/tpx3 only
#define PAR_SEND_TOA_PIXELS     "SendDummyToaPixels" // mimipix/tpx3 only
#define PAR_DUMMYSPEED          "DDDummyDataSpeed"  // no mimipix/tpx3
#define PAR_BLOCKCOUNT          "BlockCount" // no mimipix/tpx3
#define PAR_PROCESSDATA         "ProcessData" // no mimipix/tpx3
#define PAR_TRG_MULTI           "TrgMulti" // no mimipix/tpx3
#define PAR_ADVAPIX_ADC         "AdvaPixADC" // no mimipix/tpx3
#define PAR_TRG_READY           "TrgReady" // zem only
#define PAR_TRG_CMOS            "TrgCmos" // zem only
#define PAR_READOUT_CLOCK       "ReadoutClock" // zem only
```

9.3.2. Mpx2 parameter names list

```
#define PAR_LIBVER        "HwLibVer" // all, include minipixes
#define PAR_DEBUGLOG      "DebugLog" // all, include minipixes
#define CFG_BINPIXCFG     "BinaryPixelCfg" // fei-minipix only

#define PAR_FIRMWARE        "Firmware" //widepix only
#define PAR_PS_COUNT        "PreShutterClockCount"
#define PAR_PS_DIVIDER      "PreShutterClockDivider"
#define PAR_PS_DELAY        "PreShutterDelayClockCount"
#define PAR_TEMP            "Temperature" // no zem
#define PAR_BIASINCPU       "BiasInCpu" // widepix only
#define PAR_TRG_STG         "TriggerStg"
#define PAR_TRG_WAITREADY   "TriggerWaitForReady"
#define PAR_TRG_MASTER      "TriggerMaster"
#define PAR_TRG_OUTLEVEL    "TriggerOutLevel"
#define PAR_TRG_ALTERNATIVE "TriggerAlternative" // fitpix only
#define PAR_TRG_TWODEVS     "TriggerTwoDevs" // fitpix only
#define PAR_BURST_DISABLE   "BurstDisable" // fitpix only

#define PAR_CPU_BIAS_SET        "*BiasSet" // widepix only
#define PAR_CPU_BIAS_VOLTSENSE  "BiasVolt" // widepix only
#define PAR_CPU_BIAS_CURRSENSE  "BiasCurr" // widepix only
#define PAR_CPU_TEMP_DET        "TempDet" // widepix only

#define PAR_FASTACQ             "FastAcq" // zem only
#define PAR_BURST_FRAME_COUNT   "BurstFrameCount" // zem only
#define PAR_PIXEL_BUFFSIZE      "PixelBuffSize" // zem only
```

9.3.3. Mpx3 parameter names list

```
#define PAR_LIBVER              "HwLibVer"
#define PAR_DEBUGLOG            "DebugLog"
#define PAR_TEMP                "Temperature"
#define PAR_TRG_STG             "TriggerStg"
#define PAR_TRG_WAITREADY       "TriggerWaitForReady"
#define PAR_TRG_MASTER          "TriggerMaster"
#define PAR_TRG_OUTLEVEL        "TriggerOutLevel"
#define PAR_TRG_SERIES          "TriggerTdiSeries"
#define PAR_TDI_ROWCOUNT        "TdiRowCount"
#define PAR_BIASINCPU           "BiasInCpu"
#define PAR_BIAS_DISCHARGE      "BiasDischarge"

#define PAR_CPU_BIAS_SET        "*BiasSet"
#define PAR_CPU_BIAS_VOLTSENSE  "BiasVolt"
#define PAR_CPU_BIAS_CURRSENSE  "BiasCurr"
#define PAR_CPU_TEMP_DET        "TempDet"
```

9.3.4. Zest-wpxdev parameter names list

```
const static char* PAR_LIBVER = "HwLibVer";
const static char* PAR_FIRMWARE = "Firmware";
const static char* PAR_FIRMWARE_CPU = "FirmwareCpu";
const static char* PAR_DEBUGLOG = "DebugLog";
const static char* PAR_TEMP = "Temperature";
const static char* PAR_TRG_STG = "TriggerStg";
const static char* PAR_TRG_WAITREADY= "TriggerWaitForReady";
const static char* PAR_TRG_MASTER = "TriggerMaster";
const static char* PAR_TRG_OUTLEVEL = "TriggerOutLevel";
const static char* PAR_BIAS_DISCHARGE = "BiasDischarge";
```

9.3.5. Zem-wpx7dev parameter names list

```
#define PAR_LIBVER                "HwLibVer"
#define PAR_DEBUGLOG              "DebugLog"
#define PAR_PS_COUNT              "PreShutterClockCount"
#define PAR_PS_DIVIDER            "PreShutterClockDivider"
#define PAR_PS_DELAY              "PreShutterDelayClockCount"
#define PAR_ENC_PULSE_CNT         "EncoderPulseCount"
#define PAR_ENC_PULSE_DIR         "EncoderDirection"
#define PAR_ENC_PULSE_COUNTER     "EncoderPulseCounter"
```

10. The pixels matrix configuration objects

The imaging devices can create this objects to configure some pixel matrix parameters. Some devices have some parameters directly global accessible, some devices have similar parameters accessible via pixels matrix config. For example, ITpx3Dev have the setOperationMode, but IMpx2Dev have not and the pixcfg.setModeAll must be used instead. The ITpx3Dev devices creates **ITpx3Cfg** object, the IMpx2Dev (Medipix2 and Timepix) devices creates **IMpx2TpxPixCfg**.

Example:

```
pixcfg = dev.pixCfg() # Create the pixels configuration object
pixcfg.setModeAll(pixet.PX_TPXMODE_TOT)
```

10.1. General

byteSize()	Returns byte size of the object data in the memory.
size()	Returns number of pixels in the matrix.
width()	Returns pixel width of the matrix.
height()	Returns pixel height of the matrix.
pixCfgType()	Returns type of the matrix configuration. (see Constants: Pixels matrix config types)
loadFromFile(path, type**)**	Loads pixels matrix configuration. (see Constants: File types, extensions and flags)
saveToFile(path, type**)**	Saves pixels matrix config to file. (see Constants: File types, extensions and flags)
loadFromSettings(settings**)**	Loads pixels matrix config from the ISettings object
saveToSettings(settings**)**	Saves pixels matrix config to the ISettings object
setToDevice()	Sets the all the pixel matrix configuration from the object memory to the device.
setDefault()	Sets all the pixel matrix config to maskBit, testBit and thl =0, reloads dev maskbits.
destroy()	Destroys the object.

10.2. IMpx2TpxPixCfg operation modes management

Notes: Matrix mode settings **not available at all chips**. Timepix yes, Timepix3 no, for example.
See Constants: Operation modes

setMode(px, mode**)** Set the operation mode of the indexed pixel.
setModeAll(mode**)** Set the operation mode of whole device.
setModeColumn(col, mode**)** Set the operation mode of whole indexed column.
setModeColumnChip(col, ch, mode**)** Set the operation mode of whole indexed column in the indexed chip.
setModeRow(row, mode**)** Set the operation mode of whole indexed row.
setModeRowChip(row, ch, mode**)** Set the operation mode of whole indexed row in the indexed chip.
setModeRect(x, y, w, h, mode**)** Set the operation mode of whole rectangle with XY position and WH dimension.
setModeMatrix(buff, isChipByChip**)** Set the operation mode of whole device by buffer contents.
setModeMatrixChip(ch, buff**)** Set the operation mode of whole indexed chip by buffer contents.

mode(px**)** Returns operation mode of the indexed pixel.
modeAll() Returns operation mode of all the device, where was set by setModeAll.
Note: If it was later changed on part of the matrix, modeAll returns average.
modeMatrix(buff, isChipByChip**)** Read whole device mode values to the buffer.
modeMatrixChip(buff, ch**)** Read whole indexed chip mode values to the buffer.
maxMode() Returns maximum usable value of operation mode in the device.

10.3. Threshold correction bits management

setThl(px, thl**)** Set the single threshold correction value in the single indexed pixel.
setThlAll(thl**)** Set the single threshold correction value in whole device.
setThlAllChip(ch, thl**)** Set the single threshold correction value in whole indexed chip.
setThlChip(px, ch, thl**)** Set the single threshold correction value in the single indexed pixel on indexed chip.
setThlColumnChip(col, ch, thl**)** Set the single threshold correction value in whole column of the indexed chip.
setThlMatrix(buff**)** Set all the threshold correction values in whole device from the buffer.
setThlMatrixChip(ch, buff**)** Set all the threshold correction values in whole indexed chip from the buffer.
setThlRect(x, y, w, h, thl**)** Set the threshold correction value in whole rectangle on XY position with WH size.
setThlRow(row, thl**)** Set the threshold correction value in whole indexed row.

incThlColumn(row, inc, mOfr**)** Increment threshold corrections in the indexed column by the inc value.
incThlRow(row, inc, mOfr**)** Increment threshold corrections in the indexed row by the inc value.
mOfr = true: Mask pixels if result out of range / mOfr = false: No mask, only limit.
incThlCountingOver(frame, val, inc, mOfr**)**
Increment threshold by the inc value if the corresponding pixel in the frame is over the val value.

thl(px**)** Returns the threshold correction value in the single indexed pixel.
thlChip(px, ch**)** Returns the threshold correction value in the single indexed pixel on indexed chip.
thlMatrix(buff, isChipByChip**)** Read whole device threshold correction values to the buffer.
thlMatrixChip(buff, ch**)** Read whole indexed chip threshold correction values to the buffer.

averageThl() Returns the average threshold correction value in the device.
averageThlChip(ch**)** Returns the average threshold correction value in the indexed chip.

maxThl() Returns max possible value of the threshold correction in the device.

10.4. Masks management

mask(px, mask**)**	Mask (mask = true) or unmask (mask = false) the indexed single pixel.
maskAll(mask**)**	Mask (mask = true) or unmask (mask = false) whole device.
maskAllChip(ch, mask**)**	Mask (mask = true) or unmask (mask = false) whole indexed chip.
maskChip(px, ch, mask**)**	Mask (mask = true) or unmask (mask = false) single pixel on the indexed chip.
maskColumn(col, mask**)**	Mask (mask = true) or unmask (mask = false) whole indexed column in the device.
maskRow(row, mask**)**	Mask (mask = true) or unmask (mask = false) whole indexed row in the device.
maskRect(x, y, w, h, mask**)**	Mask/unmask the rectangle at XY position with WH dimensions.
maskColumnChip(col, ch, mask**)**	Mask (mask = true) or unmask (mask = false) whole column on the indexed chip.
maskRowChip(row, ch, mask**)**	Mask (mask = true) or unmask (mask = false) whole row on indexed chip.
setMaskMatrix(buff, isChipByChip**)**	Set all the mask matrix in the device by the buffer data.
setMaskMatrixChip(ch, buff**)**	Set all the mask matrix on the indexed chip by the buffer data.

maskMatrix(isChipByChip**)**	Returns list with whole the mask matrix from the device.
maskMatrixChip(buff, ch**)**	Read whole the mask matrix on the indexed chip to buffer.
maskedCount()	Returns number of masked pixels in the device.
maskedCountChip(ch**)**	Returns number of masked pixels on the indexed chip.

isMasked(px**)**	Returns 1 if indexed pixel is masked or 0 if not.
isMaskedChip(px, ch**)**	Returns 1 if indexed pixel on indexed chip is masked or 0 if not.
isMaskedColumn(col**)**	Returns 1 if all pixels on indexed column is masked or 0 if not.
isMaskedColumnChip(col, ch**)**	Returns 1 if all pixels on indexed column on indexed chip is masked or 0 if not.
isMaskedRow(col**)**	Returns 1 if all pixels on indexed row is masked or 0 if not.
isMaskedRowChip(col, ch**)**	Returns 1 if all pixels on indexed row on indexed chip is masked or 0 if not.

setSpacingPixCfg(spac, subIdx**)**	Sets mask with spacing. The chip is divided into squares of size **spac**. In each square, only the pixel of the selected **subIdx** is left active.

10.5. Test bits management

Test bits can connect each analog input pad of a readout chip to the testing pulses source. This feature is intended for testing in production, starting with uncuted waffer tests, but can be used later. The use of this feature is very complex to use and evaluate. It's **not necessary for normal use of the device**. See the chip manual for details.

Note: If you want test the chip functionality, use the **doDigitalTest()** device function, instead test-bits/pulses.

setTestBit(px, on**)**	Set test bit on/off in the indexed pixel.
setTestBitChip(px, ch, on**)**	Set test bit on/off in the indexed pixel on the indexed chip.
setTestBitAll(on**)**	Set test bit on/off in all the pixels in the device.
setTestBitAllChip(ch, on**)**	Set test bit on/off in all the pixels on the indexed chip.
setTestBitByMaskBit(on**)**	Set test bit on/off in all where are masked.
setTestBitColumn(col, on**)**	Set test bit on/off in all the pixels in the indexed column.
setTestBitColumnChip(col, ch, on**)**	Set test bit on/off in all the pixels in the indexed column on the indexed chip.
setTestBitRow(row, on**)**	Set test bit on/off in all the pixels in the indexed row.
setTestBitRowChip(row, ch, on**)**	Set test bit on/off in all the pixels in the indexed row on the indexed chip.
setTestBitRect(x, y, w, h, on**)**	Set test bit on/off in all the pixels in the rectangle at position XY and WH size.
setTestBitMatrix(buff**)**	Set test bits in the device on/off by the buffer contents.
setTestBitMatrixChip(ch, buff**)**	Set test bits on the indexed chip on/off by the buffer contents.

setTestPulseSpacingPixCfg(spac, subIdx, on**)** Sets test bits with spacing, like as the **setSpacingPixCfg**.

testBitOnCount() Returns number of test bits where are on.
testBitOnCountChip(ch**)** Returns number of test bits on the indexed chip where are on.
testBitMatrix(buff**)** Copy the test bits states to the buffer.
testBitMatrixChip(buff, ch**)** Copy the test bits states from the indexed chip to the buffer.

isTestBitOn(px**)** Returns test bit state in the indexed pixel.
isTestBitOnChip(px, ch**)** Returns test bit state in the indexed pixel on the indexed chip.
isTestBitOnColumn(col**)** Returns 1 if all the pixels in the indexed column have test bit on or 0 if some not.
isTestBitOnColumnChip(col, ch**)** Returns 1 if all the pixels in the indexed column have test bit on or 0 if not.
isTestBitOnRow(row**)** Returns 1 if all the pixels in the indexed row have test bit on or 0 if not.
isTestBitOnRowChip(row, ch**)** Returns 1 if all the pixels in the indexed row have test bit on or 0 if not.

If for some **very special reason** you would like to use this feature, it is possible with device methods:

testPulseLimits(u32* maxPulseCount, double* maxPeriod, byte* maxPhase, u32* maxCharge**)**
doSimpleTestPulseAcquisition(count, period, phase, digital, [ctpr]**)**
doAdvancedAcquisition(count, time, acqType, acqMode, fileType, fileFl, fileN**)** with PX_ACQTYPE_TESTPULSES

See the chip manual for details.

11. The IMpxDacs object

Many sensor devices containing digital-to-analog converters. These are used to set some internally used voltages and currents Refer to the device/chip datasheets for details on each channel meaning. The devices also have an ADCs to check real output values (don't confuse with **dev.adc…** functions. see Methods: Device info for it).

Notes: This is very low-level thing, direct driving of DACs is **not needed for normal device using**. Change of some DAC channels can have influence to the output data = lost of calibration.

Warnings: Using the wrong settings can cause to strange behaviour, sometimes even **damaging the device**. To correct strange behavior after experimenting with DAC values, it may be necessary to physically disconnect the power supply, wait a fewe seconds to a fewe tens of seconds, and reconnect.

Create:	**dev.dacs()**	Returns the IMpxDacs object to control the devices DACs.
	dev.createCopyOfDacs()	Returns the IMpxDacs object to store all the device DACs settings. See DACs control

Methods:

chipType()	Returns chip type on whitch is the DAC.
count()	Returns count of channels in whole the device.
singleChipCount()	Returns count of channels one sensor chip.
names()	Returns list of all channels names.
namesList(list**)**	Sets list of all channels names.
maxValue(dacIdx**)**	Returns max value of indexed DAC channel.
dac(dacIdx, chipIdx**)**	Returns value of the indexed DAC channel on the indexed chip.
setDac(dacIdx, chipIdx, value**)**	Sets value of the indexed DAC channel on the indexed chip.
setToDevice()	Apply DAC parameters stored in memory to the device.
analogDac(dacIdx, chipIdx, cnt**)**	Returns measured average output value of cnt samples or -1 if failed.
setDacAndGetAnalog(dacIdx, chipIdx, val, cnt**)**	Sets value, apply, measures real output and returns result.
setExternalDac(eDacIdx, chipIdx, val**)**	Sets external DAC. Note: Many devices have not ext. DACs.
setDefault()	Fills all of the DACs settings by defaults and apply to the device.
loadFromFile(fileName**)**	Loads all the DACs settings from file and apply to the device.
saveToFile(fileName**)**	Saves all the DACs settings to the file.
loadFromSettings(settings**)**	Loads all the DACs settings from ISettings and apply to the device.
saveToSettings(settings**)**	Stores actual DACs settings to the ISettings object.
copyFromDacs(dacs**)**	Copies DACs settings from other IMpxDacs object.
destroy()	Destroys the IMpxDacs object.

12. The IMpxFrame and other frame objects

This object can be used in frame based mode to access acquired frames. Depending on device type and operation mode, frame can contain single data block (old Medipixes), or contains subframe(s) with data blocks. Number of a subframes depending on operation mode and other device settings.

Example:

```
dev.doSimpleAcquisition(3, 1, pixet.PX_FTYPE_NONE, "")
frame = dev.lastAcqFrameRefInc()
```

12.1. Frame access and related methods

subFrameCount()	Returns number of subframes in the frame. **0:** Frame contains valid data block (IMpxNDev) or something is wrong. **1 or more:** Frame contains a data blocks with remnants of data parsing (ITpxNDev). Valid data blocks are in the subframes.
subFrames()[idx**]**	Get array of the subframes. Working if **subFrameCount** is over zero.
duplicateFrame()	Get a copy of the frame.
copyFromFrame(source**)**	Copy source frame to the frame.
asIData()	Access the frame as IData object.
destroy()	Destroy the frame object. Do this at end of work with the frame.
addSubFrame(string name**)**	Add named subframe to the frame.
removeSubFrame(idx**)**	Remove indexed subframe.
removeAllSubFrames()	Remove all subframes.
init(width, height, type**)**	Init the frame. Do this after **addSubFrame** (see Constants: Frame types).
initFromFile(path, index**)**	Init the frame. Do this after **addSubFrame** (use like as **load**)
save(path, fType, flags**)**	Save the frame data to the specified file. **path**: File name or path. **fType**, **flags**: See Constants: File types, extensions and flags
load(path, index**)**	Load the frame data from the specified file. Index is the subframe index.
lock(timeout**)**	Lock the frame to prevent access from other threads.
unlock()	Unlock the frame.
isLocked()	Returns 1 if the frame is locked or 0 if not.
ignoreMasked()	
setMask()	
data()	Gets the data array. Note: Valid data is usually in subframes.
setData(array**)**	Sets the data array.
byteSize()	Returns size of the data array in bytes.
copyDataFromFrame(source**)**	Copy data from source frame to the frame.

Data array in the ToA subframe

If **ConvertToaTime** is **enabled** on the device, this array contains the Time Of Arrival values in nanoseconds. On Tpx3 devices, values are computed from 14bit ToA counter with 40 MHz clock and refined with small fractional counter with higher clock. Maximal value is about 409,600 ns. ToA counter is resets at start of the acquisition, but fractional counter not reset. This leads to a minimal values is not zero, but can reach small negative values about -25 ns. Pixels that was not hit, contains zero.

If **ConvertToaTime** is **not enabled** on the device, this array contains only raw value of ToA counters.

Data array in the FTOA subframe

This subframe exist only if the operation mode supports ToA and **ConvertToaTime** is **not enabled** on the device. Contains raw values of the ToA fine counter.

Data array in the ToT subframe

If **useCalibration** is **enabled** on the device, this array contains energy in keV absorbed in the pixels.

If **useCalibration** is **not enabled** on the device, this array contains the Time Over Threshold values. On Tpx3 devices, this is raw values from 10bit counter. Min is 0, max 1022.

Data array in the Event subframe

This array contains Event counts. On Tpx3 devices, this is raw values from 10bit counter.

Data array in the IToT subframe

This array contains Integrated Time Over Threshold values. On Tpx3 devices, this is raw values from 14bit counter. Min is 0, max 16,383.

12.2. Frame parameters methods

frameName() Returns name of the frame. In root frame is void, in subframe contain output name.
frameType() Returns type of data in the frame (see Constants: Frame types)
width() Returns width of the frame in pixels.
height() Returns height of the frame in pixels.
size() Returns number of pixels in the frame.
device() Get device object with source device parameters.
isDeviceFrame() Returns 1 if the frame is a device frame or 0 is not.
isSubFrame() Returns 1 if the frame is a subframe or 0 is not.
startTime() Returns the system time of start acquisition.
acqTime() Returns the acquisition time in seconds.
dataFormat() Returns index of data format in the object (see Constants: Data formats).

setAcqTime() setStartTime() setDevice() setFrameName() setFrameType() Set the parameters listed above.

12.3. Frame statistics and bulk mathematic methods

min(), max(), mean(), median(), sum() Returns basic statistics of pixel data in the frame.
stdDev() Returns standard deviation.
minNonZero() Returns minimum non-zero value from pixel data in the frame.
nonZeroCount() Returns number of non-zero values in pixel data in the frame.
aboveValueCount(value**)** Returns number of values above specified.

multiplyWithFrame(frame**)** Multiply all pixel data in the frame by specified frame pixel data.
divideWithFrame(frame**)** Divide all pixel data in the frame by specified frame pixel data.

addToFrame(frame**)** Add all pixel data from specified frame to the frame pixel data.
substractFromFrame(frame**)** Subtracts all pixel data in the frame from specified frame pixel data.
multiplyWithValue(value**)** Multiply all pixel data in the frame by specified value.

fillWithValue(value**)** Fill the frame data with the value.
fillWithZeros() Fill the frame data with the zeros.

12.4. Frame metadata and his handling methods

Every frame can contain some metadata. This can be used in postprocessing. Metadata can be saved automatically with saving data to the auxiliary files (eq. DSC with TXT files). Programmer can manage it before saving files. If file saving is automatic, metadata can be managed using the beforeDataSave event (see Methods: Events).

Metatadata in DSC file example:

```
"Frame name" ("Frame name"):
char[5]
Event
```

Every metadata item contains strings Name and Description, number of the DataType and the data.

addMetaData(name, description, type, value**)** Add metadata item to the frame.
(see Related constants: Data types)
removeMetaData(name**)** Remove metadata item from the frame.
removeAllMetaData() Remove all metadata from the frame and his subframes.
hasMetaData(name**)** Returns 1 if the frame has metadata with the name.
metaDataCount() Returns number of metadata items in the frame.
metaDataNames() Get the array of a metadata names in the frame.
metaData(name**)** Access the metadata: metaData(name).data()

List of all frame's metadata example:

```
print("metaDataCount:", frame.metaDataCount())
for mdn in frame.metaDataNames():
    print("  ", mdn, frame.metaData(mdn).data())
```

12.5. Other frames methods

convertToChipByChip() Converts multi-chip frame to arrangement like as single horizontal line of chips.

convertFromChipByChip() Converts multi-chip frame from single line of chips to configured arrangement.

Note: The **chip-by-chip format** is used in low level functions

Example: dev.pixCfg().setMaskMatrix(data_chipByChip)

12.6. Frame with subframes example

```
dev.setOperationMode(pixet.PX_TPX3_OPM_TOATOT)
print("dev.doSimpleAcquisition - start")
# count, time, fileType, fileName
rc = dev.doSimpleAcquisition(count, time, pixet.PX_FTYPE_AUTODETECT, "")
print("dev.doSimpleAcquisition - end", rc)
print("acqFrameCount", dev.acqFrameCount())
for n in range(dev.acqFrameCount()):
    frame = dev.acqFrameRefInc(n)
    data = frame.data()
    print("Frame idx:", n)
    if frame.subFrameCount()>0:
        for sfr in frame.subFrames():
            print("  Subframe:", sfr.frameName())
            print("    min", sfr.min(), 'mean', sfr.mean(), 'max', sfr.max())
            data = sfr.data()
            print("    data sample:")
            print("     ", end="");
            for i in range(256*120+100, 256*120+110):
                print(data[n], end=" ")
            print()
            sfr.save("test-{}".format(n)+sfr.frameName()+".png",
                                                 pixet.PX_FTYPE_AUTODETECT, 0)
            sfr.destroy()
        #for sfr in frame.subFrames()
    else:
        print("  No subframes")
    #if frame.subFrameCount()>0
    frame.destroy()
#for n in range(dev.acqFrameCount())
```

13. The ITpx3Pixels and other pixels objects

This objects can be used in data-driven mode to direct access the measured data. Object have methods to get raw pixels data arrays or prepared data arrays and few methods to get parameters.

Example:

```
dev.doAdvancedAcquisition(1, 5, pixet.PX_ACQTYPE_DATADRIVEN, ...
pixels = dev.lastAcqPixelsRefInc()
```

13.1. Basic pixels access and related methods

totalPixelCount() Returns total pixels count over all the measurement.
pixelCount() Returns count of pixels where actually can be processed.

pixels() Get the array containing pixel position index, ToA in ns and ToT counter value.
rawPixels() Get the array containing pixel position index, cyclic ToA count, reserved, fine ToA and ToT.

Example:

```
pixels = dev.lastAcqPixelsRefInc()
pxCntTot = pixels.totalPixelCount() # All acquired pixels count
pxCnt = pixels.pixelCount()         # Pixels to be read now
pixelsData = pixels.pixels()
pixelsRaw = pixels.rawPixels()

for n in range(pxCnt):
    ind = pixelsData[0][n] # The pixel index
    toa = pixelsData[1][n] # ToA in nanoseconds
    tot = pixelsData[2][n] # Raw ToT counter value

    Rind = pixelsRaw[0][n] # The pixel index
    Rtoa = pixelsRaw[1][n] # cyclic ToA counts value
    Rres = pixelsRaw[2][n] # reserved (=0, weakly other)
    Rfto = pixelsRaw[3][n] # Raw fine ToA counter value
    Rtot = pixelsRaw[4][n] # Raw ToT counter value
```

ToA from the **pixels** method is time in nanoseconds. It is limited to 2^{31}-1 (0x7fffffff = 2,147,483,647 ns = **2.147 sec**) and overflow is indicated by value -2^{31} (-0x80000000 = -2,147,483,648).

ToA from the **rawPixels** method is time in ToA base ticks 40 MHz (25 ns/tick). Max value is 2^{31}-1 (2,147,483,647 ticks = **53.68 sec**). After overflow, value jump to -2^{31} and continues to rise for next 107,37 sec. Counting of this overflows can be used to get unlimited time.

Example with endless ns:

```
if rawToaLastSgn==0 and Rtoa<0:   # was +, now -
    rawToaLastSgn=1;
    rawToaAdd += 2**32;
elif rawToaLastSgn==1 and Rtoa>0: # was -, now +
    rawToaLastSgn=0;
ToA_ns = (Rtoa + rawToaAdd)*25 - 25/16*Rfto
```

13.2. Pixels other methods

device() Get device object with source device parameters.
dataFormat() Returns index of data format (see Constants: Data formats) normally is **TPX3_PIXELS**.
destroy() Destroy the object.

previewMpxFrame() Create a frame with preview of the pixels data.
fadeWindowSize() Return size of the time window in ns for use in **previewMpxFrame**.
setFadeWindowSize(time**)** Set the **fadeWindowSize**.
save(path, fType, flags**)** Save the data to the specified file.
path: File name or path.
fType, flags: See Constants: File types, extensions and flags
load(path, index**)** Load the data from the specified file. Index is the subframe index.
lock(timeout**)** Lock the object to prevent access from other threads.
unlock() Unlock the frame.
isLocked() Returns 1 if the object is locked or 0 if not.

13.3. Pixels metadata methods

addMetaData, **removeMetaData**, **removeAllMetaData**
hasMetaData, **metaDataCount**, **metaDataNames**, **metadata**

All metadata methods in the pixels objects are same us frame metadata methods.

For details see: Frame metadata and his handling methods

13.4. The ITpx3Pixels example: After doAcquisition

```
import pypixet

print("pixet core init...")
pypixet.start()
pixet=pypixet.pixet
dev = pixet.devicesByType(pixet.PX_DEVTYPE_TPX3)[0]

dev.setOperationMode(pixet.PX_TPX3_OPM_TOATOT)

print("doSensorRefresh start")
rc = dev.doSensorRefresh()
print("doSensorRefresh end:", rc)

print("doAdvancedAcquisition start")
rc = dev.doAdvancedAcquisition(1, 2, pixet.PX_ACQTYPE_DATADRIVEN,
                        pixet.PX_ACQMODE_NORMAL, pixet.PX_FTYPE_AUTODETECT, 0, "")
print("doAdvancedAcquisition end:", rc)

pixels = dev.lastAcqPixelsRefInc()
pxCnt = pixels.pixelCount()
pixelsData = pixels.pixels()
print("pixels count:", pxCnt)

for n in range(pxCnt):
    ind = pixelsData[0][n] # The pixel index
    toa = pixelsData[1][n] # ToA in nanoseconds
    tot = pixelsData[2][n] # Raw ToT counter value
    print("  ind ToA ToT:", ind, toa, tot)
    if n>100:
        break

pixels.destroy()
print("pixet core exit...")
pixet.exitPixet()
```

13.5. The ITpx3Pixels example: Callbacks

```
import pypixet

print("pixet core init...")
pypixet.start()
pixet=pypixet.pixet
dev = pixet.devicesByType(pixet.PX_DEVTYPE_TPX3)[0]
dev.setOperationMode(pixet.PX_TPX3_OPM_TOATOT)

print("doSensorRefresh start")
rc = dev.doSensorRefresh()
print("doSensorRefresh end:", rc)

def clbNewData(unused):
    # parameter "unused" is allways zero
    pixels = dev.lastAcqPixelsRefInc()
    pxCnt = pixels.pixelCount()
    pxCntTot = pixels.totalPixelCount()
    pixelsData = pixels.pixels()
    print("New data: pxCnt", pxCnt, "Total", pxCntTot, "------------")

    i = 0
    for n in range(pxCnt):
        ind = pixelsData[0][n] # The pixel index
        toa = pixelsData[1][n] # ToA in nanoseconds
        tot = pixelsData[2][n] # Raw ToT counter value
        x = ind % 256
        y = ind // 256
        if x>5 and x<250 and y>5 and y<250:
            print("  XY:", x, y,  "ToA", toa, "ToT", tot)
            i += 1
            if i>10:
                break

    pixels.destroy()

dev.registerEvent(pixet.PX_EVENT_ACQ_NEW_DATA, 0, clbNewData)
print("doAdvancedAcquisition start")
rc = dev.doAdvancedAcquisition(1, 2, pixet.PX_ACQTYPE_DATADRIVEN,
                         pixet.PX_ACQMODE_NORMAL, pixet.PX_FTYPE_AUTODETECT, 0, "")
print("doAdvancedAcquisition end:", rc)
dev.unregisterEvent(pixet.PX_EVENT_ACQ_NEW_DATA, 0, clbNewData)
print("pixet core exit...")
pixet.exitPixet()
```

14. The pypxproc object

This object can create data processing objects that can work with clusters from data that comes best from data-driven mode.

Clustering(dev**)** Get the Clustering object. It can processing a single clusters to looking for interesting single particles and the like.

SpectraImaging(dev**)** Get the SpectraImg object. It can process many clusters into pixels in images, select clusters by energy range, or sort to energy channels..
Syntax note: The name is from Spectra Imaging, not SpectraL imagnig)

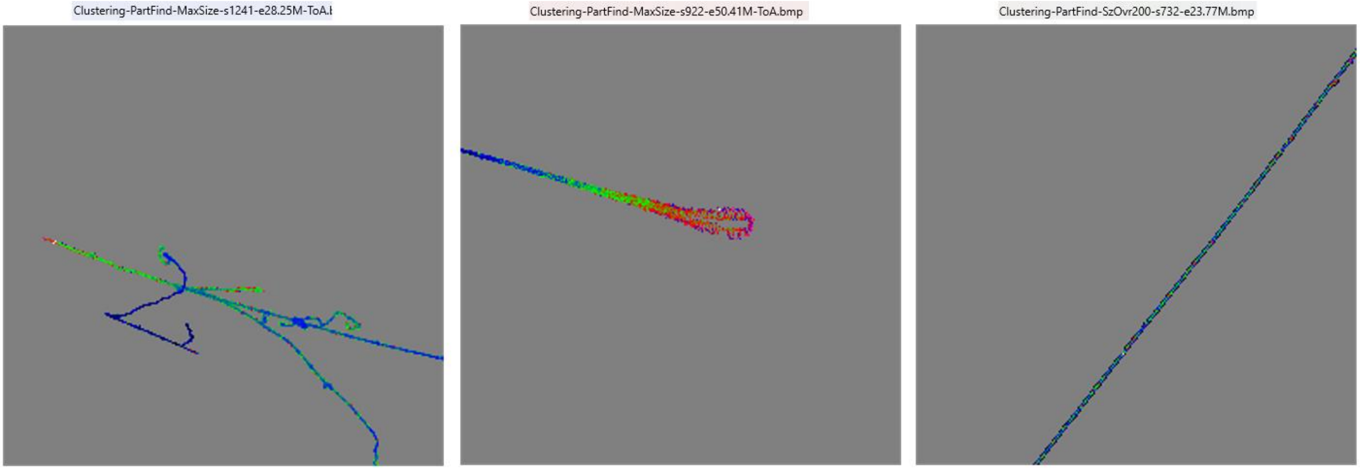
The methods listed above can be used with or without parameter. If not used, only offline processing is possible.

Example1:

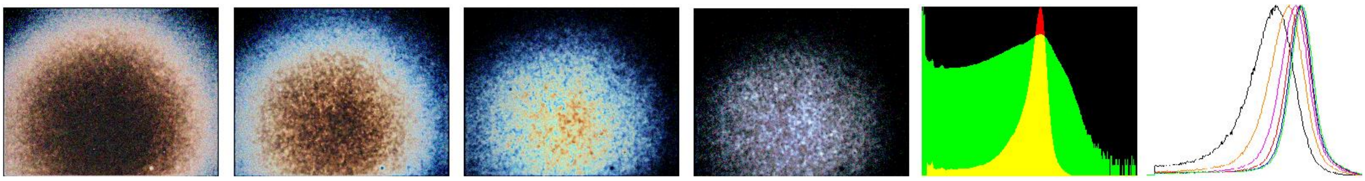
```
si = pypxproc.SpectraImaging()             # offline proces only
```

Example2:

```
devices = pixet.devices()
dev = devices[0]
si = pypxproc.SpectraImaging(dev.asIDev()) # can use the device
```


Clustering-PartFind-MaxSize-s1241-e28.25M-ToA.I
Clustering-PartFind-MaxSize-s922-e50.41M-ToA.bmp
Clustering-PartFind-SzOvr200-s732-e23.77M.bmp

Clustering - Sample output from an experiment



SpectraImg - Sample output from an experiment

15. The Clustering object and related

The Clustering object is designed for easy work with clusters of the pixels. Typically used to determine energy and other parameters of high energy particles.

15.1. The Clustering methods

loadCalibrationFromDevice() Load the calibration data from IDev connected to the Cl.
loadCalibrationFromFiles(path**)** Loads ABCT calibration from single XML file. Device config file can be used.
loadCalibrationFromFiles(pathA|pathB|pathC|pathT**)** Load ABCT calibration data from set of text files.
isCalibrationLoaded() Returns 1 if calibration is loaded or 0 if not.

replayData(pathIn, pathOut, blocking**)** Process data from the input file.
Input can be tpx3 pixels: t3pa, t3r, t3p.
Process the data and calls the corresponding callbacks for further cluster processing.
If calibration is loaded, energy values will be calibrated.
If the output path defined and ending with .clog, cluster log will be saved.
If the blocking is true, program wait to process end, if false, processing is started in a separate thread.

Example:

```
cl.replayData("input.t3pa", "output.clog", True)
```

startMeasurement(acqTime, measTime, pathOut**)** Start the measurement. Only if the SI connected to the IDev.
Measurement works in the background. Use while-isRunning() to wait for end, if need it.
measTime: Total time [s] of the measurement. Use 0 to endless measurement (progress will always 100%).
acqTime: Primary for frame-based devices (Medipixes, Timepix, no Tpx3): This is single frame time.
Use a short enough time to prevent clusters overlapping. Too short time can cause too many losses between frames. On data-driven devices (Timepix3, no Timepix), this is the ToA limit. After exceeds, ToA is resets and acqIndex in the newClusters… callbacks is incremented.

pathOut: Output file path. For data-driven devices (eq Timepix3) required pixel files: t3pa, t3r, t3p
For Frame-based devices (eq Medipix, Timepix) required cluster log files: clog

processData: True/false, enable/disable online processing.
Warning: Online processing can cause data loss due to insufficient computing power.

isRunning() Returns 1 if clustering process is running or 0 if not.

Example:

```
print("starting measurement...")
rc = cl.startMeasurement(1, 100, "")
while cl.isRunning():
      pass
print("meas. end, rc:", rc, "(0 is OK)")
```

15.2. The Clustering properties

messageCallback Name of the callback function for message receiving (errCode, messageString).
progressCallback Name of the callback function for process progress monitoring (progPercent, finishedNum). Occurs approximately twice per second.
acqStartedCallback Name of the callback function for acquisition started (acqIndex).
acqFinishedCallback Name of the callback function for acquisition finished (acqIndex).
newClustersCallback Name of the callback function for new clusters parameters using (clusters, acqIndex).
newClustersWithPixelsCallback Name of callback function for new clusters data processing (clusters, acqIndex).

The callback parameter "clusters" get the **Clusters** object. This can be simply used like us array to get the **Cluster** object. The Cluster object from the newClustersWithPixelsCallback can be used to get array of the **Pixel** objects.

15.3. The Clusters object

The **Clustering** object have the callback functions named **newClustersCallback** and **newClustersWithPixelsCallback**. His first parameter can be used to get the **Clusters** object containing a clusters. Normally is used as an array of the **Cluster** objects.

Example:

```
def newClustersCb(clusters, acqIndex):
    for i in range(len(clusters)):
        cluster = clusters[i]
```

15.4. The Cluster object

The Cluster object contains a single cluster data. Total size, total energy, position, roundness and can include list of his pixels.

id Order number of the cluster.
toa Time of arrival of first cluster's pixel.
x, y Position of the cluster. This is not normal integer position of one pixel, it's computed cluster center.
size Number of pixels in the cluster.
height Pixel size of the cluster.
roundness 1 for an ideal circle with area equal to cluster.size, decreasing by a number related to the ratio of the inscribed circle vs. circumscribed circle.
e Total energy in the cluster. If the calibration loaded, e is energy in keV, if not, e is sum of pixels ToTs.
pixels Array of the **Pixel** objects. Only if the cluster is from the **newClustersWithPixelsCallback**.

15.5. The Pixel object

Single pixel data from the cluster which was obtained from the **newClustersWithPixelsCallback**.

toa Time of arrival of first cluster's pixel.
x, y Position of the pixel.
e Energy absorbed in the pixel. If the calibration loaded, e is energy in keV, if not, e is the ToT value.

15.6. The Clustering examples

15.6.1. Simple list of the clusters

This example only shows sample lists of the clusters with it’s parameters using the **newClustersCallback**:

```
import pypixet, pypxproc

def messageCb(error, msg): # =======================================================
    print("*** ErrCode: {}, msg: {}".format(error, msg))

def progressCb(finished, progress): # ==============================================
    print("*** Progress: {:.2f} %, finished={}".format(progress, finished))

def newClustersCb(clusters, acqIndex): # ===========================================
    print("*** NewClusters: cnt={},  acqIndex={}".format(len(clusters), acqIndex))
    for i in range(len(clusters)):
        cluster = clusters[i]
        print("{}: x={}, y={}, e={:.2f}, toa={:.2f}, size={}, height={:.2f}".format(
            i, int(cluster.x), int(cluster.y), cluster.e, cluster.toa, cluster.size,
            cluster.height))
        if i > 20:
            break

print("pixet core init...")
pypixet.start()
pixet=pypixet.pixet
devices = pixet.devicesByType(pixet.PX_DEVTYPE_TPX3)
dev = pixet.devices()[0]

cl = pypxproc.Clustering(dev.asIDev())
cl.messageCallback = messageCb
cl.progressCallback = progressCb
cl.newClustersCallback = newClustersCb


rc = cl.loadCalibrationFromDevice()
print("Load calib", rc)

# startMeasurement(acqTime, measTime, outputFilePath)
rc = cl.startMeasurement(2, 30, "")
print("startMeasurement", rc)

while cl.isRunning():
    pass

print("Exit pixet...")
pixet.exitPixet()
```

15.6.1. List of the clusters with pixels sample

This example only shows sample lists of the clusters with it’s parameters and lists of it’s pixels, using the **newClustersWithPixelsCallback**:

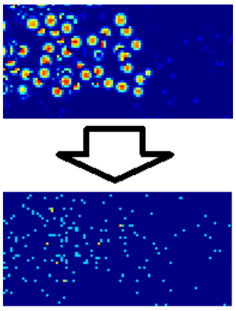
```
import pypixet, pypxproc

def messageCb(error, msg): # =======================================================
    print("*** ErrCode: {}, msg: {}".format(error, msg))

def progressCb(finished, progress): # ==============================================
    print("*** Progress: {:.2f} %, finished={}".format(progress, finished))

def newClustersWithPixelsCb(clusters, acqIndex): # =================================
    print("*** NewClustersWPx: cnt={},  acqIndex={}".format(len(clusters), acqIndex))
    for i in range(len(clusters)):
        cluster = clusters[i]
        print("{}: x={}, y={}, e={:.2f}, toa={:.2f}, size={}, height={:.2f}".format(
            i, int(cluster.x), int(cluster.y), cluster.e, cluster.toa, cluster.size,
            cluster.height))
        for pix in cluster.pixels:
            print("  [{}, {}, {:.2f}, {:.2f}]".format(
                  int(pix.x), int(pix.y), pix.e, pix.toa))
        if i > 20:
            break

print("pixet core init...")
pypixet.start()
pixet=pypixet.pixet
devices = pixet.devicesByType(pixet.PX_DEVTYPE_TPX3)
dev = pixet.devices()[0]

cl = pypxproc.Clustering(dev.asIDev())
cl.messageCallback = messageCb
cl.progressCallback = progressCb
cl.newClustersWithPixelsCallback = newClustersWithPixelsCb

rc = cl.loadCalibrationFromDevice()
print("Load calib", rc)

rc = cl.startMeasurement(2, 30, "")
print("startMeasurement", rc)

while cl.isRunning():
    pass

print("Exit pixet...")
pixet.exitPixet()
```

15.6.2. The clusters statistics using newClustersCallback

This can be used in program like as previous example. Display some statistics of clusters in each set and global histogram lists after the process ends.

```
def newClustersCb(clusters, acqIndex):
    try:
        lc = len(clusters)
        print("\n*** NewClusters: count={},  acqIndex={}".format(lc, acqIndex))
        e = 0
        em = 0
        s = 0
        sm = 0
        for cluster in clusters:
            eChan = int(cluster.e / newClustersCb.chansEneStep)
            sChan = int(cluster.size / newClustersCb.chansSizStep)
            newClustersCb.chansEne[eChan] += 1
            newClustersCb.chansSiz[sChan] += 1
            e += cluster.e
            if cluster.e>em: em = cluster.e
            s += cluster.size
            if cluster.size>sm: sm = cluster.size
        print("  Sum sizes", s, "Sum E {:.2f} MeV,".format(e/1000),
            "clust.S: avg {:.2f} px/cl, max {:.2f},".format(s/lc, sm),
            "clust.E: avg {:.2f} keV/cl, max {:.2f}M".format(e/lc, em/1000))
    except:
        traceback.print_exc()

newClustersCb.chansEneStep = 30000/250
newClustersCb.chansSizStep = 4
newClustersCb.chansEne = [0] * 256
newClustersCb.chansSiz = [0] * 256
# def newClustersCb

# ... (initialize, load calibration, measuring or replay data)

while cl.isRunning():
    pass

print("newClustersCb.chansEne", newClustersCb.chansEne)
print("newClustersCb.chansSiz", newClustersCb.chansSiz)
```

16. The SpectraImg object



The SpectraImg is designed for easy working with an energy spectras. It can work with previous saved data using the **replayData** method or with physical device. For offline mode create the SpectraImg using **pypxproc.SpectraImaging()**. For online mode, the device must be normally initialized by the Pixet object, convert to IDev using device's **asIDev()** method and connected using **pypxproc.SpectraImaging(**idev**)**. Pixels in the generated frames have values from clusters detected in the input data.
Warning: Online processing can cause data loss due to insufficient computing power.

Example (online):

```
import pypixet, pypxproc

print("pixet core init...")
pypixet.start()
pixet=pypixet.pixet
devices = pixet.devicesByType(pixet.PX_DEVTYPE_TPX3)
dev = devices[0]
si = pypxproc.SpectraImaging(dev.asIDev())
```

Example (offline):

```
import pypxproc
si = pypxproc.SpectraImaging()
```

Steps for using this object in the online mode:

1. Initialize the Pixet core and create the device object (skip core init if starting from the Pixet program).
2. Optionally use the sensor refresh or dummy acq.
3. Create the SpectraImg object using IDev object converted from the device.
4. Set-up the callbacks.
5. Load device calibration (**loadCalibrationFromDevice** or **loadCalibrationFromFiles**).
6. Set measurement parameters using the **setMeasParams** and possibly **setXrfParams** methods.
7. Start the measurement using **startMeasurement**.
8. Wait for measurement and processing is complete (and display the progress) using while-**isRunning**.
9. Use some get… method and use the data.
10. Deinitialize the Pixet core.

Steps for using this object in the offline mode:

1. Create the Spectraimg object using empty parentheses.
2. Set-up the callbacks.
3. Load device calibration using **loadCalibrationFromFiles**.
4. Set measurement parameters using the **setMeasParams** and possibly **setXrfParams** methods.
5. Use the **replayData** instead of a measurement and process data from the t3pa file.
6. Wait for processing complete (and display the progress) using while-**isRunning**.
(If goal is only get the clog file, this is end)
7. Use some get… method and use the data.

Using BSTG files to save processing time:

1. After processing is complete (end of waiting steps above), use the **saveToFile(**"file.bstg"**)** method.
2. Anytime use the **loadFromFile(**"file.bstg"**)** method and continue using the data as it was processed.

16.1. SpectraImg auxiliary methods and properties

loadCalibrationFromDevice() Loads the calibration data from the device that is connected to the SI as an IDev. (see The pypxproc object)
loadCalibrationFromFiles(path**)** Loads ABCT calibration data from single XML file. Device config file can be used.
loadCalibrationFromFiles(pathA|pathB|pathC|pathT**)** Load ABCT calibration data from set of text files.
isCalibrationLoaded() Returns 1 if calibration is loaded to the SpectraImg object or 0 if not.

messageCallback Name of callback function for message receiving (errCode, messageString). Occurs at start of a processing and on errors.
progressCallback Name of callback function for process progress monitoring (progPercent, finishedNum). Occurs every approximately 1 second.

Examples:

```
si.messageCallback = messageClbFun
si.loadCalibrationFromFiles("cal_a.txt|cal_b.txt|cal_c.txt|cal_t.txt")
```

loadFromFile(path**)** Load the previous measured+processed data and device configuration from the BSTG file.
saveToFile(path**)** Save the measured and processed data and device configuration to the BSTG file.
saveSumFrame(path, zoom, correct**)** Save all data to one text frame. Zoom 1/2/3. Sub-pixels correction True/False. The txt ASCII matrix file with space separated decimal float numbers at lines.
saveDataAsSpectrumToFile(path**)** Save text file with tab-separated cols for all energy steps and lines for all pixels. The step size [keV] and count is depends on previous used **setMeasParams** method.

measuredPixelsPerSecond() Returns actual measuring speed in pixels per second.
processedPixelsPerSecond() Returns actual data processing speed in pixels per second.

16.2. Spectraimg measurement and related methods

setMeasParams(from, to, step, maskNP, doSPC**)** Sets spectral parameters of future data processing. No return value.

from: Spectral range start [keV].
to: Spectral range end [keV].
step: Step width in the spectrum [keV].
The from/to/step are source of energy indexes used in get… methods listed bellow.
maskNP: Mask (true) or not mask (false) noisy pixels.
doSPC: Perform (true) or not perform (false) subpixel correction.

setXrfParams(minVol, maxVol, distance, toaDiff, reserved, correctXrf**)** Set X-ray fluorescence parameters. No return value.

minVol: Minimum XRF cluster volume (energy).
maxVol: Maximum XRF cluster volume (energy).
distance: Fluorescent pixels maximal distance.
toaDiff: Fluorescent pixels time difference (depends on chip material and thickness).
reserved: Reserved for future use: enable Remove XRF events.
correctXrf: Enable (true) or disable (false) XRF correction. Detected XRF energy will replaced by 25 keV.

startMeasurement(acqTime, measTime, pathOut, processData**)** Start the measurement (physical device).

Measurement works in the background. Use while-isRunning() to wait for end, if need it.
measTime: Total time of the measurement.

acqTime: Single frame time. Used only on frame-based devices (Timepix using, Timepix3 ignoring).
Use a short enough time to prevent clusters overlapping. Too short time can cause too many losses.
pathOut: Output file path. Must ends with .clog.
processData: True/false, enable/disable online processing.
Warning: Online processing can cause data loss due to insufficient computing power.

replayData(pathIn, pathOut, reserved**)** Use data from the input file like as in measuring.
Input can be pixels: t3pa, t3r, t3p, frames: pmf, txt, h5, bmf, plog, or clog.
Processes the data from input file and calls the corresponding callbacks.
If calibration is loaded, energy values will be calibrated.
If the output path defined and ending with .clog, cluster log will be saved.
The process works in the background. Use while-isRunning() to wait for end, if need it.

Example:
```
si.replayData("input.t3pa", "output.clog", 0)
```

isRunning() Returns 1 if process is running or 0 if not.

Data processing note:
Measurement (with processData=True) and relapy data first identify a clusters, using XRF parameters, next divides clusters into groups according to MeasParams.

getFrameForEnergy(energyIndex, sumFrame, normalize, zoom**)** Gets image from selected energy range.
Returns the return code and the frame.
Returned frame is 2-dimmensional array with sizes of the sensor multiplied by the zoom factor.
energyIndex: Index of energy range. Ranges must be set using the **setMeasParams** method.
sumFrame: Gets summary frame (True) and ignore index or gets the single energy range (False).
normalize: Enable normalize of the image (True/False).
zoom: Zoom factor of sumFrame. Usable values are 1 and 2.
Single energies not zoomed, but allowed values are 1/2 too.

Example:
```
rc, frame = si.getFrameForEnergy(13, False, False, 1)
```

getFrameForEnergyRange(energyFromIndex, energyToIndex, normalize**)** Gets image from selected energy range.
Returns the return code and the frame.
Returned frame is 2-dimmensional array with sizes of the sensor with sum from the selected ranges.
energyFromIndex: Index of first energy range. Ranges must be set using the **setMeasParams** method.
energyToIndex: Index of last energy range. Ranges must be set using the **setMeasParams** method.
normalize: Enable normalize of the image (True/False).

getGlobalSpectrum() Gets the global energy spectrum. Returns return code, the spectrum array and step size.
Array size and step size [keV] is depends on previous used **setMeasParams** method.

Example:
```
rc, spectrum, step = si.getGlobalSpectrum()
```

getGlobalSpectrumInRect(left, top, right, bottom**)** Same us the **getGlobalSpectrum()** but in the rectangle defined by corners positions.

Example:
```
rc, spectrum, step = si.getGlobalSpectrumInRect(x1, y1, x2, y2)
```

Note: The smaller the rectangle, the more data is needed.

16.3. SpectraImg constants and error codes

```
// Contants:
#define SI_API_VERSION 1
#define SI_INVALID_HANDLE 0
#define SI_NO_DEVICE -1


// Error Codes:
#define SI_ERR_CANNOT_LOAD_PIXET -1
#define SI_ERR_PIXET_NOT_LOADED -2
#define SI_ERR_INVALID_HANDLE -3
#define SI_ERR_INVALID_DEVICE_INDEX -4

#define SI_ERR_INVALID_ARGUMENT -100
#define SI_ERR_CALIB_DIMENSION_MISTMATCH -101
#define SI_ERR_CANNOT_OPEN_FILE -102
#define SI_ERR_CANNOT_READ_FRAME -103
#define SI_ERR_CANNOT_MEASURE -104
#define SI_ERR_LOCK_TIMEOUT -105
#define SI_ERR_DIMENSION_MISTMATCH -106
#define SI_ERR_NO_DATA -107
#define SI_ERR_INVALID_RECT -108
#define SI_ERR_CANNOT_READ_FILE -109
#define SI_ERR_CANNOT_SAVE_FILE -110
```

16.4. SpectraImg examples

16.4.1. Simple measuring and list of the spectrum (Tpx3 only)

```
import pypixet
import pypxproc

print("pixet core init...")
pypixet.start()
pixet=pypixet.pixet
devices = pixet.devicesByType(pixet.PX_DEVTYPE_TPX3)
dev = devices[0]

si = pypxproc.SpectraImaging(dev.asIDev())

print("Load calibration...")
rc = si.loadCalibrationFromDevice()
print("rc", rc , "0 is OK")

# setMeasParams(from, to, step, maskNP, doSPC)
si.setMeasParams(0, 300, 10, True, False)

print("Start measurement...")
# si.startMeasurement(acqTime (frame-only devs), measTime, outFile, processData)
rc = si.startMeasurement(1, 10, "", True)
print("rc", rc , "0 is OK")
print("measuring...")

while si.isRunning():
    pass # It is the simplest, but has twice the CPU usage than time.sleep(...)

print("Get global spectrum...")
rc, spect, step = si.getGlobalSpectrum()
print("rc={} Spectrum in {} chans, with step {} keV:".format(rc, len(spect), step))
print(spect)

pixet.exitPixet()
```

16.4.2. Begin and end for online mode examples

```
import pypixet, pypxproc, time, sys, os
from saveBMP import *

def messageCb(error, msg): # ===========================================
    print("** ErrCode:", error, "Message:", msg)

def progressCb(finished, progress): # ==================================
    if finished==0:
        if progressCb.prevProc == -1 or progressCb.prevProc < progress-10:
            print("\nProgress: {:.2f} %".format(progress), end=" ")
            progressCb.prevProc = progress
        else:
            sys.stdout.write('.')
            sys.stdout.flush()
    else:
        print("\nFinished")

progressCb.prevProc = -1

try: # create dirrectory for file output
    os.makedirs("out-files")
except FileExistsError:
    pass # already exists

print("pixet core init...")
pypixet.start()
pixet=pypixet.pixet
devices = pixet.devices()
if devices[0].fullName()=="FileDevice 0":
    print("  No devices connected")
    pixet.exitPixet()
    exit()

dev = devices[0]

si = pypxproc.SpectraImaging(dev.asIDev())

si.messageCallback = messageCb
si.progressCallback = progressCb

rc = si.loadCalibrationFromDevice()
print("Load calib, rc", rc)

# here place the working code ←--------------------------------------------

print("pixet core exit...")
pixet.exitPixet()
```

16.4.3. Measuring and getFrameForEnergy

```
# (insert between the "Begin and end for online...")

# setMeasParams(from, to, step, maskNP, doSPC)
si.setMeasParams(0, 5000, 250, True, False)
# The clusters will be sorted into 250 keV wide bands, first at 0, last at 5000,
# noisy pixels masked, subpixel correction Off

print("Start measurement...")
#si.startMeasurement(acqTime (ignore at data-driven devs), measTime, outFile, processData)
rc = si.startMeasurement(1, 40, "", True)
print("rc", rc, "(0 is OK)")
print("measuring...")

while si.isRunning(): # wait for end of measuring and processing
    time.sleep(0.1)

print("Get spectrum...")
rc, spect, step = si.getGlobalSpectrum()
chans = len(spect)
print("rc={}. Spectrum in {} channels, with step {} keV:".format(rc, chans, step))
print(spect)
print()

print("Get frame for energy (sum frame)")
# getFrameForEnergy(energyIndex, sumFrame, normalize, zoom)
rc1, fr = si.getFrameForEnergy(2, True, False, 1) # get the sum frame
print("  rc", rc1, "(0 is OK)")

# saveWithLogNormFrameToFile(framesRGB, fName, fIdx=-1, desc="")
saveWithLogNormFrameToFile([fr, fr, fr], "out-files/SpectraImg-GFFE-sum")
# (save function from python examples environment: saveBMP.py)

for n in range(0, chans-2, 3):
    # generate triplets of a single channel frames to use in RGB images
    info = "E_{:.1f}-{:.1f}_keV".format(n*step, (n+2)*step)
    print("Get frame for energy: idx", n, info)
    # getFrameForEnergy(energyIndex, sumFrame, normalize, zoom)
    rc1, fb = si.getFrameForEnergy(n+0, False, False, 1)
    rc2, fg = si.getFrameForEnergy(n+1, False, False, 1)
    rc3, fr = si.getFrameForEnergy(n+2, False, False, 1)
    print("  rc", rc1, rc2, rc3, "(0 is OK)")

    # saveWithLogNormFrameToFile(framesRGB, fName, fIdx=-1, desc="")
    saveWithLogNormFrameToFile([fr, fg, fb], "out-files/SpectraImg-GFFE", n, info)
```

(this example is part of the **tpx3-spectrum-gFfE-bmp.py** example file)

16.4.4. Measuring and getFrameForEnergyRange

```python
# (insert between the "Begin and end for online...")

# setMeasParams(from, to, step, maskNP, doSPC)
si.setMeasParams(0, 5120, 20, True, False)
# The clusters will be sorted into 20 keV wide bands, first at 0, last at 5120,
# noisy pixels masked, subpixel correction ON

print("Start measurement...")
#si.startMeasurement(acqTime (ignore at data-driven devs), measTime, outFile, processData)
rc = si.startMeasurement(1, 40, "", True)
print("rc", rc, "(0 is OK)")
print("measuring...")

while si.isRunning():
    time.sleep(0.1)

for n in range(0, chans-15, 15):
    print("Get frames for energy range:", n)
    # getFrameForEnergyRange(energyFromIndex, energyToIndex, normalize)
    rc1, fb = si.getFrameForEnergyRange(n+0,  n+4,  True)
    rc2, fg = si.getFrameForEnergyRange(n+5,  n+9,  True)
    rc3, fr = si.getFrameForEnergyRange(n+10, n+14, True)
    print("  rc", rc1, rc2, rc3, "(0 is OK)")

    # saveWithLogNormFrameToFile(framesRGB, fName, fIdx=-1)
    saveWithLogNormFrameToFile([fr, fg, fb], "out-files/SpectraImg-gFfER", n)
    # (save function from python examples environment: saveBMP.py)
```

(this example is part of the **tpx3-spectrum-gFfER-bmp.py** example file, adapted for online processing)

16.4.5. Offline data processing

```
import pypixet, pypxproc, sys, time, os
from saveBMP import *

def messageCb(error, msg): # ===========================================
    print("** Message callback: ErrCode:", error, "Message:", msg)

def progressCb(finished, progress): # ==================================
    if finished==0:
        if progressCb.prevProc == -1 or progressCb.prevProc < progress-10:
            print("\nProgress: {:.2f} %".format(progress), end=" ")
            progressCb.prevProc = progress
        else:
            sys.stdout.write('.')
            sys.stdout.flush()
    else:
        print("\nFinished")

progressCb.prevProc = -1

print("pixet core init...")
pypixet.start()
pixet=pypixet.pixet
devices = pixet.devices()
si = pypxproc.SpectraImaging(dev.asIDev())

si.messageCallback = messageCb
si.progressCallback = progressCb

print("Load calibration...")
rc = si.loadCalibrationFromDevice()
print("rc", rc, "(0 is OK)")

# setMeasParams(from, to, step, maskNP, doSPC)
si.setMeasParams(0, 256*15, 15, True, True) # 0-3840 keV, step 15

print("replay data start")
# replayData(pathIn, pathOut, reserved)
rc = si.replayData("out-files/SpectraImg-data.t3pa", "", 0)
print("rc", rc, "(0 is OK)")
print("processing...")

while si.isRunning():
    time.sleep(0.1)

# Now yoy can use processed data by si.getGlobalSpectrum, getFrameForEnergy, ...
```

Notes:

The device is not required for offline processing. In this example it’s only as source of calibration data.

Alternative start with no device is:

```
si = pypxproc.SpectraImaging()
print("Load calibration...")
rc = si.loadCalibrationFromFiles("config.xml") # the device config file
print("rc", rc, "(0 is OK)")
```

You can also use
`si.loadCalibrationFromFiles("cal_a.txt|cal_b.txt|cal_c.txt|cal_t.txt")`
to load only ABCT configuration data instead of whole config.xml.

(The offline data processing is used in more SpectraImg examles: **tpx3-spectrum-gFfER-bmp.py, tpx3-spectrum-gGSiR-bmp.py**, …)

16.4.6. Get a data for the offline processing

```
import pypixet, os

try: # create dirrectory for file output
    os.makedirs("out-files")
except FileExistsError:
    pass # already exists

print("pixet core init...")
pypixet.start()
pixet=pypixet.pixet
devices = pixet.devices()
dev = devices[0]
dev.setOperationMode(pixet.PX_TPX3_OPM_TOATOT)

dataFileName = "out-files/example-data.t3pa"

print("doAdvancedAcquisition...")
#doAdvancedAcquisition(acqCount, acqTime, acqType, acqMode, fileType, fileFlags, fName)
rc = dev.doAdvancedAcquisition(1, acqTime, pixet.PX_ACQTYPE_DATADRIVEN,
            pixet.PX_ACQMODE_NORMAL, pixet.PX_FTYPE_AUTODETECT, 0, dataFileName)
print("  rc", rc, "(0 is OK)")

print("Exit pixet...")
pixet.exitPixet()
```

Note: If your device not support data-driven mode, frame mode and frame files must be used. Set short acqTime to prevent clusters overwriting and more acqCount to obtain sufficient amount of data.

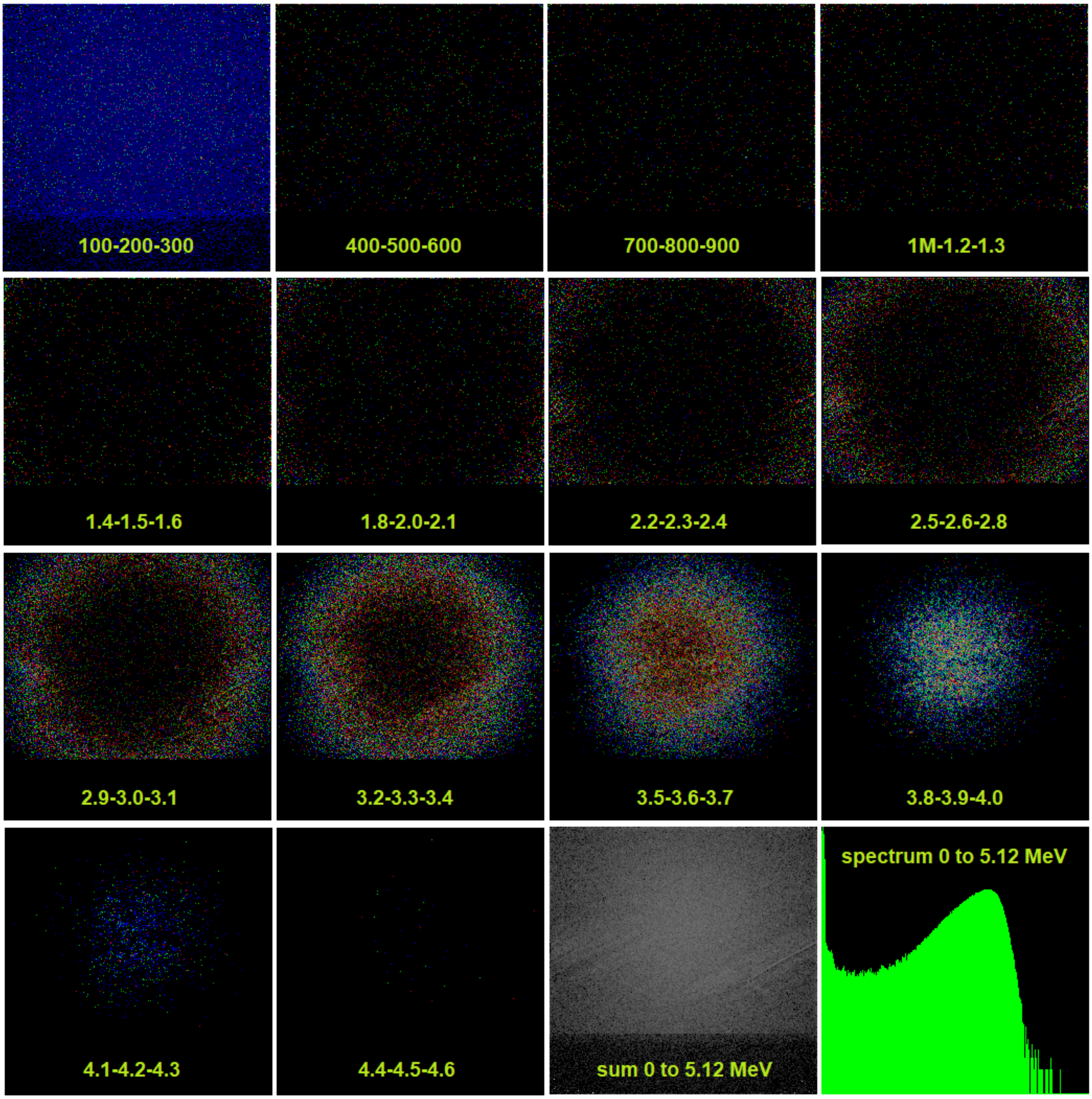
16.4.7. Save processed data to BSTG file for future use

```
# (insert between the "Begin and end for online...")

# setMeasParams(from, to, step, maskNP, doSPC)
si.setMeasParams(0, 5000, 250, True, False)

print("Start measurement...")
#si.startMeasurement(acqTime (ignore at data-driven devs), measTime, outFile, processData)
rc = si.startMeasurement(1, 40, "", True)
print("rc", rc, "(0 is OK)")
print("measuring...")

while si.isRunning(): # wait for end of measuring and processing
    time.sleep(0.1)

print("Save bstg...")
rc = si.saveToFile("out-files/SpectraImg.bstg")
print("rc", rc, "(0 is OK)")
```

16.4.8. Load and use previous saved BSTG data

```
import pypxproc
from saveBMP import *

print("Starting pypxproc.SpectraImaging...")
si = pypxproc.SpectraImaging()

print("Load bstg...")
rc = si.loadFromFile("out-files/SpectraImg.bstg")
print("rc", rc, "(0 is OK)")

# Now you can use processed data as it was saved

print("Get spectrum...")
rc, spect, step = si.getGlobalSpectrum()
chans = len(spect)
print("rc={}. Spectrum in {} channels, with step {} keV:".format(rc, chans, step))
print(spect)
print()

print("pixet core exit...")
pixet.exitPixet()
```

16.4.9. Measuring examples results (getFrameForEnergyRange)



^{241}Am from smoke detector, located 3 mm above the chip, MinipixTpx3, CdTe 2 mm, acq. time 45 seconds.
Settings used: `setMeasParams(0, 5120, 20, True, False) # (from, to, step, maskNP, doSPC)`

Each RGB color channel in images was generated from sum of 5 energy ranges (100 keV), using the **getFrameForEnergyRange** method, log2(val+0.5) applied and normalized to 0-255. Order is blue-green-red.
The blue at the first image is gamma byproduct 59.5 keV and noise in the first band. The images with MeV ranges shows a 5.48 MeV alpha particles attenuated in air.

Summary frame shows all hits in the set range. It was get using the **getFrameForEnergy** method with sumFrame=True. A “scrathes” on the picture: SpectraImg is very sensitive to small differences in px sensitivity.

The spectrum on last image was get using the **getGlobalSpectrum** method and processed like us pixels data, include using log2. A gaps on the right are caused by no hits.

17. The pygui object

This object provides a graphical environment. If the script using it, must be run from the Pixet program's Python plugin. The pygui using .UI files with XML format, whitch is compatible with UI files from the Qt Creator. Graffical items can be also generated by code, withour an UI file.

loadFromUiString(xmlstring**)** Load window or widget definition from XML string. Returns the Window object.
loadFromUiFile(uiFilePath**)** Load window or widget definition from XML file. Returns the Window object.
MainWindow() Create the new Window object for future use with code-generated components.

showMessage(title, message**)** Shows the system messagebox, info type. Returns none.
showWarning(title, message**)** Shows the system messagebox, warning type. Returns none.
showError(title, message**)** Shows the system messagebox, error type. Returns none.
showQuestion(title, message**)** Shows the system messagebox, question Yes/No type. Returns 1 or 0.

showItemSelection(title, message, itemsArray, defaultIndex, editable**)**
Shows the Select Item dialog to select from array of string items.
User can optionally edit selected item.
Returns the selected string or default string item if the Cancel clicked.
inputText(title, label**)** Shows the Input type dialog. Returns string or None if the Cancel clicked.

getOpenFileName(name, filter**)** Shows the File Open dialog. Returns the file path or None if the Cancel clicked.
getExistingDirectory(name**)** Shows the Select Folder dialog. Returns the file path or None if the Cancel clicked.
getSaveFileName(name, filter**)** Shows the Save as… dialog. Returns the file path or None if the Cancel clicked.
getSaveFileNameAndFilter(name, filter**)** Some as getSaveFileName, but returns array with path and selected filter.

File filters variants:

1. Single filter: Only filtering string "*.txt"
2. Single filter with description: Description (filter) "Text files (*.txt)"
3. Multiple filters in single select item: Space separated list "*.txt *.csv"
4. Multiple filter items to select: List separated by the ;; (double ;) "*.txt;;*.csv"
5. Combined example: "Images (*.png *.xpm *.jpg);;Text files (*.txt);;XML files (*.xml)"

Examples:

```
import pygui

pygui.showMessage("Window title", "Message text")
pygui.showWarning("Window title", "Message text")
pygui.showError("Window title", "Message text")
print(pygui.showQuestion("Window title", "Question text"))
print(pygui.showItemSelection("Title", "Message", ["item0", "item1"], 0, False))
print(pygui.showItemSelection("Title", "Message", ["item0", "item1"], 0, True))

print(pygui.inputText("Window title", "Question text"))
print(pygui.getOpenFileName("", "*.txt"))
print(pygui.getExistingDirectory(""))
print(pygui.getSaveFileName("test.txt", "*.txt"))
print(pygui.getSaveFileNameAndFilter("test.txt", "*.txt;;*.csv"))

window = pygui.MainWindow()
print(window)
window.show()
```

18. The Window and associated objects

This is graphical window object created by the pygui object, using methods **loadFromUiString**, **loadFromUiFile** or empty object from **MainWindow**.

The Window methods:

show()	Shows the window.
hide()	Hides the window.
setTitle(title**)**	Sets title of the window.
setPosition(x, y**)**	Sets position of the window.
setSize(width, height**)**	Sets size of the window.
processEvents()	Process waiting events associated with the window.
setLayout(layout**)**	Sets layout of the window, using the GridLayout object.
newGridLayout()	Creates and returns a GridLayout object.
Label(title**)**	Creates and returns a Label object.
Button(title**)**	Creates and returns a PushButton object.
ToolButton()	Creates and returns a ToolButton object.
CheckBox(title**)**	Creates and returns a CheckBox object.
RadioButton()	Creates and returns a RadioButton object.
ComboBox()	Creates and returns a ComboBox object.
SpinBox()	Creates and returns a SpinBox object.
DoubleSpinBox()	Creates and returns a DoubleSpinBox object.
LineEdit()	Creates and returns a LineEdit object.
TextEdit()	Creates and returns a TextEdit object.
Slider()	Creates and returns a Slider object.
ProgressBar()	Creates and returns a ProgressBar object.
PropertyTreeView()	Creates and returns a PropertyTreeView object.
ListWidget()	Creates and returns a ListWidget object.
Widget()	Creates and returns a Widget object.
GroupBox()	Creates and returns a GroupBox object.
MpxFrame()	Creates and returns a MpxFrame object.
MpxFramePanel()	Creates and returns a MpxFramePanel object.
Plot()	Creates and returns a Plot object.

Using of the Window object via pygui.MainWindow():

1. Create the window using some as **window = pygui.MainWindow()**
2. Create the objects that you plan to use in the window using some as **lab = window.Label(**"Text"**)**
3. Create the GridLayout using some as **gl = window.newGridLayout()**
4. Add objects created in 2 to layout using some as **gl.addWidget(**lab, 0, 0, 1, 1**)**
5. Set your layout to the window using some as **window.setLayout(**gl**)**
6. Show the window using some as **window.show()**

The GroupBox and Widget objects can be used similarly as a Window:

Create new graphical objects using methods of the Window object, create the GroupBox, create GridLayout, add objects to the GridLayout and set GridLayout to the GroupBox. Now you can use the GroupBox as other obejcts in the Window.

18.1. The GridLayout object and its methods

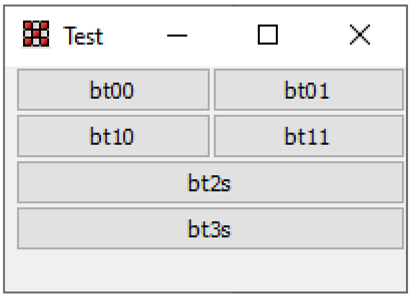
The GridLayout object are using to set layout of the objects in the Window object.

setSpacing(pixels**)** Sets pixel spacing size in the grid.
setVerticalSpacing(pixels**)** Sets vertical spacing between objects in the GridLayout.
setHorizontalSpacing(pixels**)** Sets horizontal spacing between objects in the GridLayout.
setContentsMargins(left, top, right, bottom**)** Sets margins around all of the GridLayout's contents.
setRowStretch(row, stretch**)** Sets stretch factor* of the row.
setColumnStretch(column, stretch**)** Sets stretch factor* of the column.
spacing() Returns spacing in the grid.
verticalSpacing() Returns vertical spacing in the grid.
horizontalSpacing() Returns horizontal spacing in the grid.
addWidget(widget, row, col, rowSpan, colSpan**)** Adds widget-type object to the GridLayout to the row/col position. The **rowSpan** and **colSpan** is number of coupled rows or columns occupied by the object.
rowCount() Returns count of rows in the grid.
columnCount() Returns count of columns in the grid.

* The **stretch factor** is relative to the other columns in this grid. Columns/rows with a higher stretch factor take more of the available space.

Example:

```
import pygui

window = pygui.MainWindow()
window.setTitle("Test")
bt00 = window.Button("bt00")
bt01 = window.Button("bt01")
bt10 = window.Button("bt10")
bt11 = window.Button("bt11")
bt2s = window.Button("bt2s")
bt3s = window.Button("bt3s")
gl = window.newGridLayout()
gl.addWidget(bt00, 0, 0, 1, 1)
gl.addWidget(bt01, 0, 1, 1, 1)
gl.addWidget(bt10, 1, 0, 1, 1)
gl.addWidget(bt11, 1, 1, 1, 1)
gl.addWidget(bt2s, 2, 0, 1, 2)
gl.addWidget(bt3s, 3, 0, 1, 2)
gl.setSpacing(0)
gl.setContentsMargins(5, 0, 0, 20)
window.setLayout(gl)
window.show()
```



18.2. The Widget, TabWidget and GroupBox objects

Widget and Groupbox are an objects for graphical arrangement. GroupBox is visible and can have label, Widget is invisible. The TabWidget can be used to switch Widgets by a tabs.

You can use hierarchical arrangement:

1. Create a GridLayout and a Widget/Groupbox.
2. Insert some objects to the GridLayout using the **addWidget** method.
3. Set the GridLayout to your Widget/Groupbox using the **setLayout** method.
4. Insert your Widget/Groupbox to the parent layout using the **addWidget** method.

18.2.1. The Widget object and its methods

Create: **window.Widget()**

setPosition(x, y**)**	Sets position of the widget in the parent area.
setSize(width, height**)**	Sets size of the widget.
setLayout(layout**)**	Sets layout of the widget, using a GridLayout object.
Show(visible**)**	Shows/hides the widget.

18.2.2. The GroupBox object and its methods

Create: **window.GroupBox()**

setPosition(x, y**)**	Sets position of the widget in the parent area.
setSize(width, height**)**	Sets size of the widget.
setLayout(layout**)**	Sets layout of the widget, using a GridLayout object.
Show(visible**)**	Shows/hides the widget.
setTitle(text**)**	Sets the label text.
setStyleSheet(styleSheetText**)**	Sets style of the label text. Example: **box.setStyleSheet(**"color: red"**)**

18.2.3. The TabWidget object and its methods

Create: (only in UI file or string)

addTab(widget, name**)**	Adds a new tab with name and associated with defined widget.
removeTab(index**)**	Removes the indexed tab.
setCurrentIndex(index**)**	Changes active tab to index.
currentIndex()	Returns index of the active tab.
setTabText(index, text**)**	Sets text of the indexed tab.
setEnabled(en**)/isEnabled()**	Enables/disables and returns enable state.
setMinimumSize/setMaximumSize	Sets size limits (width, height) for window arrangement and resize.

It has the “**changed**” event. Occurs on change of the active tab index.

18.3. The PropertyTreeView object and its methods

PropertyTreeView from the QT. Tree contains string-named groups. Groups contains string-named properties. Properties can be strings, ints, doubles, bools and lists. Properties can be editable or view only. Numeric values have an allowed range min-max, doubles also have precision. Values can be added using **add…** methods, changed using **set…** methods, reads using the **getProperty** or you can clear all using the **clear** method.

Create: **window.PropertyTreeView()**

addInt(group, name, value, min, max, isEditable**)** Adds int-type property with allow min/max range.
addDouble(group, name, value, min, max, prec, isEditable**)** Adds double-type property with min/max, precision.
addBool(group, name, value, isEditable**)** Adds bool-type property.
addString(group, name, value, isEditable**)** Adds a string-type property.
addList(group, name, [values], isEditable**)** Adds a list-type property.

getProperty(group, name**)** Returns value of the property.

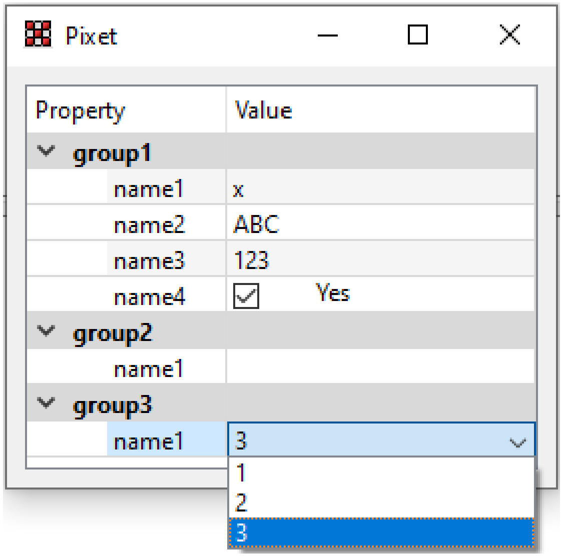
setInt(group, name, value**)** Changes the int-type property value.
setDouble(group, name, value**)** Changes the double-type property value.
setBool(group, name, value**)** Changes the bool-type property value.
setString(group, name, value**)** Changes the string-type property value.
setList(group, name, [values]**)** Changes list in the list-type property.
setListSelectedText(group, name, selValue**)** Changes the list-type property selected value.

expandAll(isExpanded**)** Expands/collapses all groups.
clear() Clears whole the PropertyTreeView.
setColumnWidth(col, width**)** Sets width of the column.
setEnabled(en**)/isEnabled()** Enables/disables and returns enable state.
setMinimumSize/setMaximumSize Sets size limits (width, height) for window arrangement and resize.

List-type properties notes:

- The essence of the list-type value is which list element is selected.
- New list-type property has no selected item and the **getProperty** returns nothing.
- The **setListSelectedText** can set string that is not in the list and this disappears if editable value is clicked.

```
window = pygui.MainWindow()
ptv = window.PropertyTreeView()
ptv.addList("group1", "name1", ["a", "b", "c"], 1)
ptv.addList("group2", "name1", ["A", "B", "C"], 1)
ptv.addList("group3", "name1", ["1", "2", "3"], 1)
ptv.addString("group1", "name2", "ABC", 1)
ptv.addInt("group1", "name3", 123, 0, 200, 1)
ptv.addBool("group1", "name4", 1, 1)
ptv.setListSelectedText("group1", "name1", "x")
ptv.setListSelectedText("group3", "name1", "3")
ptv.expandAll(1)
gl = window.newGridLayout()
gl.addWidget(tst, 0, 0, 1, 1)
window.setLayout(gl)
window.show()
```



Property	Value
group1	
name1	x
name2	ABC
name3	123
name4	☑ Yes
group2	
name1	
group3	
name1	3 1 2 3

18.4. The MpxFrame object and its methods

This is the sizable viewer of detector frame data with color range description bar and position/value tooltip.

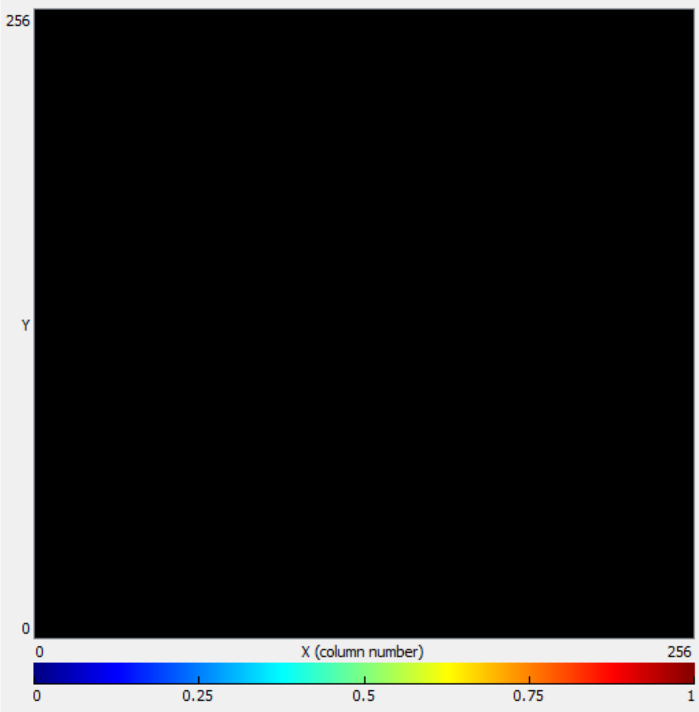
Create: **window.MpxFrame()**

showColorBar(show**)**	Show/hide color range description bar.
showAxis(show**)**	Show/hide axis.
showGrid(show**)**	Show/hide pixel grid (usefull with high zoom).
keepAspectRatio(keep**)**	Enable/disable keep aspect ratio while resizing window.
setUnderWarning(show**)**	Enable/disable
setOverWarning(show**)**	Enable/disable
setMirrored(isMirrored**)**	Mirror/don't mirror the image.
setRotation(rotation**)**	Rotate the image.
setColorMap(colorMapIndex**)**	Switch color map. Range 0 (grayscale), 1 to 8 (colorized).
setRange(min, max**)**	Sets range for colorizing.
range()	Returns list with min and max from colorizing range.
setData([data], width, height)	Sets the image data.
setEnabled(en**)/isEnabled()**	Enable/disable and returns enable state.
setMinimumSize/**setMaximumSize**	Sets size limits (width, height) for window arrangement and resize.

Events:

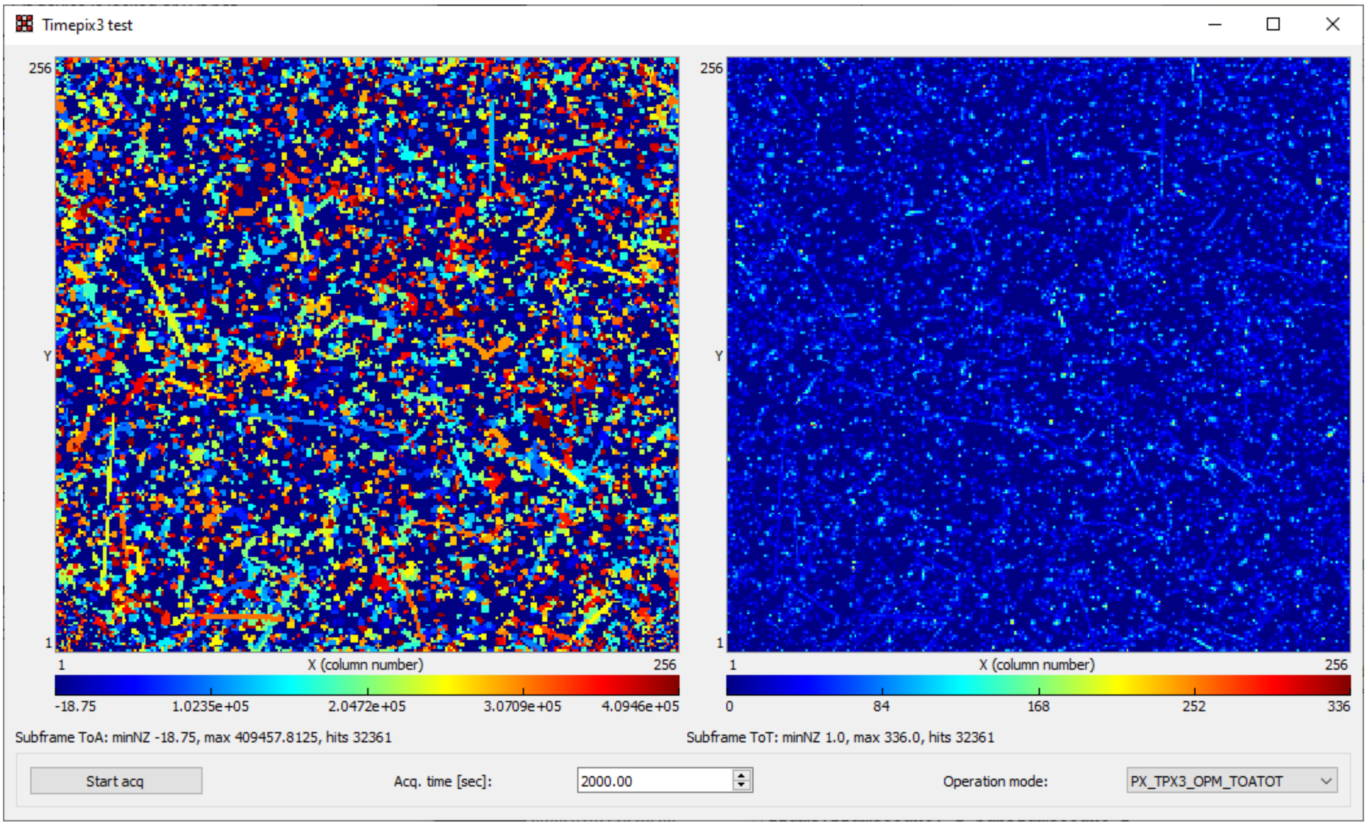
clicked	Occurs at mouse button press. Callback parameters: **(x, y, button)**
selRectsChanged	Occurs after moving mouse while Ctrl hold. Parameters: **(**list of **[x, y, width, height])**
zoomRectChanged	Occurs after moving mouse while button hold. Parameters: **(**single **[x, y, width, height])**

MpxFrame with ColorMap 1



18.4.1. Timepix3 measuring with MpxFrame widget example

```
import pygui
devs = pixet.devicesByType(pixet.PX_DEVTYPE_TPX3)

def btnStart_Clicked(): # ====================================================
    if len(devs)>0:
        btnStart.setEnabled(0)
        sbAcqTime.setEnabled(0)
        lab0.setText("Working...")
        lab1.setText("")
        window.processEvents()
        acqSimple(sbAcqTime.value(), cmbOPM.currentIndex())
        btnStart.setEnabled(1)
        sbAcqTime.setEnabled(1)
    else:
        pygui.showError("Error", "No devices found")

def frameInfo(fr): # =========================================================
    return "Subframe {}: minNZ {}, max {}, hits {}".format(fr.frameName(),
fr.minNonZero(), fr.max(), fr.nonZeroCount())

def acqSimple(time, opm): # ==================================================
    print("acqSimple %i sec, opm %i ----------------" % (time, opm))
    dev.setOperationMode(opm)
    print("dev.doSimpleAcquisition - start")
    rc = dev.doSimpleAcquisition(1, time, pixet.PX_FTYPE_AUTODETECT, "")
    print("dev.doSimpleAcquisition - end %i" % rc)
    if rc!=0:
        lab0.setText("Error in acq: %i" % rc)
        return

    print("acqFrameCount %i" % dev.acqFrameCount())
    frame = dev.acqFrameRefInc(0)
    print("frame.frameCount: %i subFrameCount %i" % (frame.frameCount(),
frame.subFrameCount()))
    data = frame.data()
    if frame.subFrameCount()>0:
        f0=frame.subFrames()[0]
        lab0.setText(frameInfo(f0))
        print(lab0.text())
        mpfr0.setRange(f0.min(), f0.max())
        mpfr0.setData(f0.data(), 256, 256)
        if frame.subFrameCount()>1:
            f1=frame.subFrames()[1]
            lab1.setText(frameInfo(f1))
            print(lab1.text())
            mpfr1.setRange(f1.min(), f1.max())
            mpfr1.setData(f1.data(), 256, 256)
    frame.destroy()
    window.processEvents()
# def acqSimple

# ===========================================================================
if len(devs)>0:
    dev = devs[0]
    print(dev)
    pars = dev.parameters()
    tcpu = pars.get("TemperatureCpu").getDouble()
    tchip = pars.get("TemperatureChip").getDouble()
    fw = pars.get("FirmwareCpu").getString()
    print("CPU Temp: %f, Chip Temp: %f, FirmwareCpu: %s" % (tcpu, tchip, fw))
    print("==================================================================")

    print("dev.loadConfigFromDevice %i" % dev.loadConfigFromDevice())
else:
    print("No devices found")

window = pygui.MainWindow()
window.setTitle("Timepix3 test")
mpfr0 = window.MpxFrame()
mpfr1 = window.MpxFrame()
mpfr0.setMinimumSize(512, 512)
mpfr1.setMinimumSize(512, 512)
mpfr0.setColorMap(1)
mpfr1.setColorMap(1)
lab0 = window.Label("Left frame: No data")
lab1 = window.Label("Right frame: No data")
btnStart = window.Button("Start acq")
btnStart.clicked = btnStart_Clicked
labNone1 = window.Label("")
labAcqTime = window.Label("Acq. time [sec]:")
sbAcqTime = window.DoubleSpinBox()
sbAcqTime.setMaximum(1000000)
sbAcqTime.setValue(5)
labNone2 = window.Label("")
labOPM = window.Label("Operation mode:")
cmbOPM = window.ComboBox()
cmbOPM.setItems(["PX_TPX3_OPM_TOATOT", "PX_TPX3_OPM_TOA", "PX_TPX3_OPM_EVENT_ITOT"])

glwin = window.newGridLayout() # layout of the window
glgr = window.newGridLayout() # layout of groupbox
gr = window.GroupBox()
gr.setLayout(glgr)

glwin.addWidget(mpfr0, 0, 0, 1, 1)
glwin.addWidget(mpfr1, 0, 1, 1, 1)
glwin.addWidget(lab0,  1, 0, 1, 1)
glwin.addWidget(lab1,  1, 1, 1, 1)
glwin.addWidget(gr,    2, 0, 1, 2)

glgr.addWidget(btnStart,   0, 0, 1, 1)
glgr.addWidget(labNone1,   0, 1, 1, 1)
glgr.addWidget(labAcqTime, 0, 2, 1, 1)
glgr.addWidget(sbAcqTime,  0, 3, 1, 1)
glgr.addWidget(labNone2,   0, 4, 1, 1)
glgr.addWidget(labOPM,     0, 5, 1, 1)
glgr.addWidget(cmbOPM,     0, 6, 1, 1)

window.setLayout(glwin)
window.show()
```



Subframe ToA: minNZ -18.75, max 409457.8125, hits 32361

Subframe ToT: minNZ 1.0, max 336.0, hits 32361

Acq. time [sec]: 2000.00

Operation mode: PX_TPX3_OPM_TOATOT

18.5. The MpxFramePanel object and its methods

Graphical object like as MpxFrame, but with panel containing usesfull controls.

Create: **window.MpxFramePanel()**

Methods different from MpxFrame:

showSaveButton(show**)**	Show/hide the "Save image" button.
showGridButton(show**)**	Show/hide the "Show grid" button.
showRotateButton(show**)**	Show/hide the "Rotate clockwise" button.
showAutoRangeButton(show**)**	Show/hide the "Auto range" button.
showColorMapButton(show**)**	Show/hide the "Color map" button.
showUnderButton(show**)**	Show/hide the "Under warming" button.
showOverButton(show**)**	Show/hide the "Over warming" button.
setAutoRange(isAutoRange**)**	Enable/disable auto range for image colorizing.

Methods identical with MpxFrame:

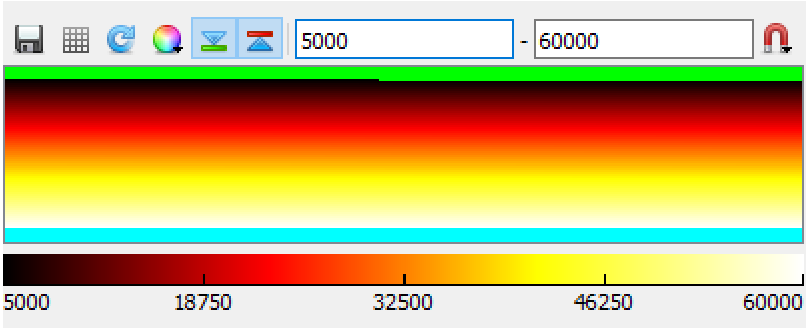
showColorBar(show**)**	Show/hide color range description bar.
showAxis(show**)**	Show/hide axis.
showGrid(show**)**	Show/hide pixel grid (usesfull with high zoom).
keepAspectRatio(keep**)**	Enable/disable keep aspect ratio while resizing window.
setUnderWarning(show**)**	Enable/disable
setOverWarning(show**)**	Enable/disable
setMirrored(isMirrored**)**	Mirror/don't mirror the image.
setRotation(rotation**)**	Rotate the image.
setColorMap(colorMapIndex**)**	Switch color map. Range 0 (grayscale), 1 to 8 (colorized).
setRange(min, max**)**	Sets range for colorizing.
range()	Returns list with min and max from colorizing range.
setData([data], width, height**)**	Sets the image data.
setEnabled(en**)/isEnabled()**	Enable/disable and returns enable state.
setMinimumSize/setMaximumSize	Sets size limits (width, height) for window arrangement and resize.

Events (identical with MpxFrame):

clicked	Occurs at mouse button press. Callback parameters: **(x, y, button)**
selRectsChanged	Occurs after moving mouse while Ctrl hold. Parameters: **(**list of **[x, y, width, height])**
zoomRectChanged	Occurs after moving mouse while button hold. Parameters: **(**single **[x, y, width, height])**

Range and under/over warming example:

The MpxFramePanel is filled with 0-65535 values



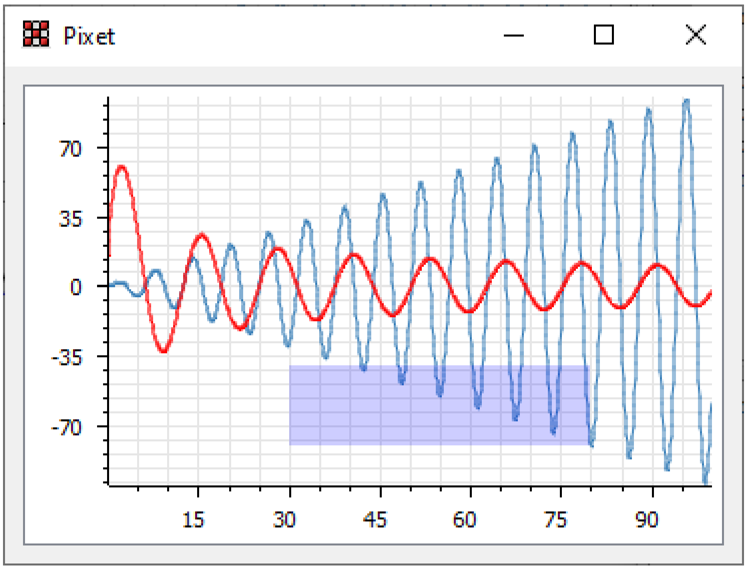
5000 - 60000

18.6. The Plot object and its methods

Graphical object designed to showing a graphs. Supports layers, zooming, autosize, highlights.

Plot have a layers.
Use **addLayer()** for add next layer and **clear()** to delete all except 1 layers.
Layer have a Lines, BarLines, Scatters and Highlights.
Use **addLine(**layerIdx**)** for add line to the indexed layer.
Line have a pixels coupled to continuous line. Whole line have one color.
Use **addPoint(**layerIdx, lineIdx, x, y**)** for add point or **replacePoint** to change Y value.
Or use **setLineData(**layerIdx, lineIdx, [xs], [ys]**)** to set all line points.
BarLine is some as Line, indexed as Line, but area under whole graph is filled.
Maintaining of a BarLine is some as for Line.
Scatter is some as Line, but points are separated and can have various colors using colorized “Z axis”.
Use **addScatterPoint(**layerIdx, scatterIdx, x, y, z, repaint**)** for add point to the scatter.
Highlight is highlighted area on the layer. Have a HighlightRect.
Use **setHighlightRect(**layerIdx, highlightIdx, x1, x2, y1, y2**)** for define area.

Example:



```
import pygui, math

window = pygui.MainWindow()
plot = window.Plot()
plot.setMinimumSize(350, 230)
gl = window.newGridLayout()
gl.addWidget(plot, 0, 0, 1, 1)
window.setLayout(gl)
window.show()

datax = []
datay0 = []
datay1 = []
for n in range(1, 1000):
    x = n/10
    datax.append(x)
    datay0.append(x * math.sin(x))
    datay1.append(100/math.sqrt(x) * math.sin(x/2))

plot.addLine(0)
plot.addLine(0)
plot.setLineData(0, 0, datax, datay0)
plot.setLineData(0, 1, datax, datay1)
plot.setLineColor(0, 1, 255, 0, 0)

plot.addHighlight(0)
plot.setHighlightRect(0, 0, 30, 80, -80, -40)
plot.setHighlightColor(0, 0, 0, 0, 255, 50)
plot.update()
```

Create: **window.Plot()**

addLayer()/layerCount() Adds new layer / Returns count of layers. Default is 1.
clear() Clears whole plot to layerCount 1.
showLayer(layerIdx, show**)** Shows/hides the indexed layer.
clearLayer(layerIdx**)** Clears all Lines, BarLines, Scatters and Highlights in the layer to count 0.
update() Updates all. Lines, colors, Scatter points with False repaint.

addLine(layerIdx**)/addBarLine(**layerIdx**)** Adds new line/barLine to the indexed layer.
lineCount(layerIdx**)** Returns count of (bar)lines on the indexed layer. Default is 0.
clearLine(layerIdx, lineIdx**)** Clears the indexed (bar)line to pointCount 0.
setLineData(layerIdx, lineIdx, [xs], [ys]**)** Sets data of whole the indexed (bar)line.
showLine(layerIdx, lineIdx, show**)** Shows/hides the indexed (bar)line.
setLineWidth(layerIdx, lineIdx, width**)** Sets width of the indexed (bar)line.
setLineColor(layerIdx, lineIdx, r, g, b**)** Sets color of the indexed (bar)line.
addPoint(layerIdx, lineIdx, x, y**)** Adds a single point to the indexed (bar)line.
replacePoint(layerIdx, lineIdx, x, y**)** Replaces a single point in the indexed (bar)line.
pointCount(layerIdx, lineIdx**)** Returns counts of points in the indexed (bar)line.

addScatter(layerIdx**)** Adds new scatter to the indexed layer.
scatterCount(layerIdx**)** Returns count of scatters on the indexed layer. Default is 0.
addScatterPoint(layerIdx, scatterIdx, x, y, z, repaint**)** Adds a single scatter point. Z is color index to the ColorMap.
clearScatter(layerIdx, scatterIdx**)** Clears all points in the indexed scatter on the indexed layer.
setScatterColorMap(layerIdx, scatterIdx, colorMapIdx**)** Sets ColorMap applied to Z parameter of scatter points.
setScatterPointSize(layerIdx, scatterIdx, width, height**)** Sets size of the scatter points.
showScatter(layerIdx, scatterIdx, show**)** Shows/hides the indexed scatter.

addHighlight(layerIdx**)** Adds new highlight to the indexed layer.
highlightCount(layerIdx**)** Returns count of highlights in the indexed layer.
setHighlightRect(layerIdx, highlightIdx, x1, x2, y1, y2**)** Sets highlighted zone rectangle coordinates.
highlightRect(layerIdx, highlightIndex**)** Returns list of coordinates of the indexed highlight.
setHighlightMode(layerIdx, highlightIdx, enabled**)** Enables/disables the indexed highlight.
setHighlightColor(layerIdx, highlightIdx, r, g, b, alpha**)** Sets color and transparency % of the indexed highlight.

setAutoRangeX/setAutoRangeY Enables/disables lower and upper autoranges on X/Y. **(lowerOn, upperOn)**
setRangeX/setRangeY/setRangeZ Sets lower and upper ranges of line axis and of Z in scatter. **(lower, upper)**
setTitle(title**)** Sets the plot tittle text.
showTitle(show**)** Shows/hides the plot tittle text.
setLabelX(text**)/setLabelY(**text**)** Sets the axis labels texts.
showLabelX(show**)/showLabelY(**show**)** Shows/hides the axis labels texts.
showAxisX(show**)/showAxisY(**show**)** Shows/hides the axises.
showColorBar(show**)** Shows/hides color-mapping bar for scatters.
setRightLegend/setBottomLegend Sets the lines legends on the indexed layer **(layerIdx, [items])**.
showRightLegend(show**)/showBottomLegend(**show**)** Shows/hides axis legends.
setEnabled(en**)/isEnabled()** Enable/disable and returns enable state.
setMinimumSize/setMaximumSize Sets size limits (width, height) for window arrangement and resize.

No events.

18.7. Other graphical objects and its methods

Label

Simple system label, create: **window.Label(**"text"**)**

setText(text**)/text()** Sets and returns label text.
setEnabled(en**)/isEnabled()** Enable/disable and returns enable state (disabled = gray).
setMinimumSize/setMaximumSize Sets size limits (width, height) for window arrangement and resize.
setStyleSheet(styleSheetText**)** Sets style of the label text. Example: **label.setStyleSheet(**"color: red"**)**

CheckBox

Simple system checkbox, create: **window.CheckBox(**"text"**)**

setText/text, **setEnabled/isEnabled**, **setMinimumSize/setMaximumSize** – Same as Label.
setChecked(check**)/isChecked()** Sets and returns check status.

It has the “**clicked**” event. Occurs on button clicked.

RadioButton

Simple system radiobutton, create: **window.RadioButton()**

(All methods and events are same as in the CheckBox.)

PushButton

Simple system button, create: **window.Button(**"text"**)**

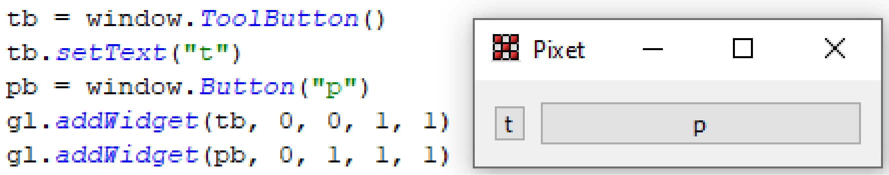
setText/text, **setEnabled/isEnabled**, **setMinimumSize/setMaximumSize** – Same as Label.

It has the “**clicked**” event. Occurs on button clicked.

ToolButton

Smaller button than PushButton, without default text, create: **window.ToolButton()**

PushButton
vs
ToolButton



```
tb = window.ToolButton()
tb.setText("t")
pb = window.Button("p")
gl.addWidget(tb, 0, 0, 1, 1)
gl.addWidget(pb, 0, 1, 1, 1)
```

SpinBox

Spinbox for int-type numbers (line edit with +/- buttons), create: **window.SpinBox()**

setValue(val**)/value()** Sets and returns the value.
setMaximum(val**)/maximum()** Sets and returns the maximal allowed value.
setMinimum(val**)/minimum()** Sets and returns the minimal allowed value.
setStep(val**)/step()** Sets and returns the step of +/- buttons.
setEnabled(en**)/isEnabled()** Enable/disable and returns enable state.
setMinimumSize/setMaximumSize Sets size limits (width, height) for window arrangement and resize.

DoubleSpinBox

Spinbox for double-type numbers (line edit with +/-), create: **window.DoubleSpinBox()**

(All methods are same as in the SpinBox.)

ComboBox

Simple system combobox, create: **window.ComboBox()**

setCurrentIndex(val**)/currentIndex()** Sets and retutns the list index.
currentText() Returns current text.
setItems([items]**)** Sets items list.
setEnabled(en**)/isEnabled()** Enable/disable and returns enable state.
setMinimumSize/setMaximumSize Sets size limits (width, height) for window arrangement and resize.

It has the “**changed**” event. Occurs on value changed.

LineEdit

Single line text edit frame, create: **window.LineEdit()**

setText/text, **setEnabled/isEnabled**, **setMinimumSize/setMaximumSize** – Same as Label.

TextEdit

Multiline text edit frame, create: **window.TextEdit()**

setText/text, **setEnabled/isEnabled**, **setMinimumSize/setMaximumSize** – Same as Label.
append(text**)** Appends a text to the edit.
clear() Clear text in the edit.

Slider

Slider with “regulator” style, create: **window.Slider()**

setValue(val**)/value()** Sets and returns the slider position value.
setSliderPosition(val**)/sliderPosition()** Some as setValue/value.
setMaximum(val**)/maximum()** Sets and returns the highest slider value.
setMinimum(val**)/minimum()** Sets and returns the lowest slider value.
setSingleStep(val**)/singleStep()** Sets and returns the step of up/down arrow keys.
setPageStep(val**)/pageStep()** Sets and returns the step of pageUp/pageDown keys.
setEnabled(en**)/isEnabled()** Enable/disable and returns enable state.
setMinimumSize/setMaximumSize Sets size limits (width, height) for window arrangement and resize.
setStyleSheet(styleSheetText**)** Sets style of the text. Example: **slider.setStyleSheet(**"color: red"**)**

It has the “**changed**” event. Occurs on value changed.

ProgressBar

Progressbar with percents, create: **window.ProgressBar()**

setValue(val**)/value()** Sets and returns the bar position value.
setMaximum(val**)/maximum()** Sets and returns the highest bar value.
setMinimum(val**)/minimum()** Sets and returns the lowest bar value.
setEnabled(en**)/isEnabled()** Enable/disable and returns enable state.
setMinimumSize/setMaximumSize Sets size limits (width, height) for window arrangement and resize.
setStyleSheet(styleSheetText**)** Sets style of the text. Example: **bar.setStyleSheet(**"color: red"**)**

ListWidget

Simple system listview, create: **window.ListWidget()**

setItems([items]**)**	Sets items list.
setItemChecked(index, check**)**	Sets checked state of the indexed item.
setItemSelected(index, sel**)**	Sets selected state of the indexed item.
itemText(index**)**	Returns text from the indexed item.
selectedIndexes()	Returns list of selected items indexes.
checkedIndexes()	Returns list of checked items indexes.
setEnabled(en**)/isEnabled()**	Enable/disable and returns enable state.
setMinimumSize/**setMaximumSize**	Sets size limits (width, height) for window arrangement and resize.

It has the “**changed**” event. Occurs on value changed.