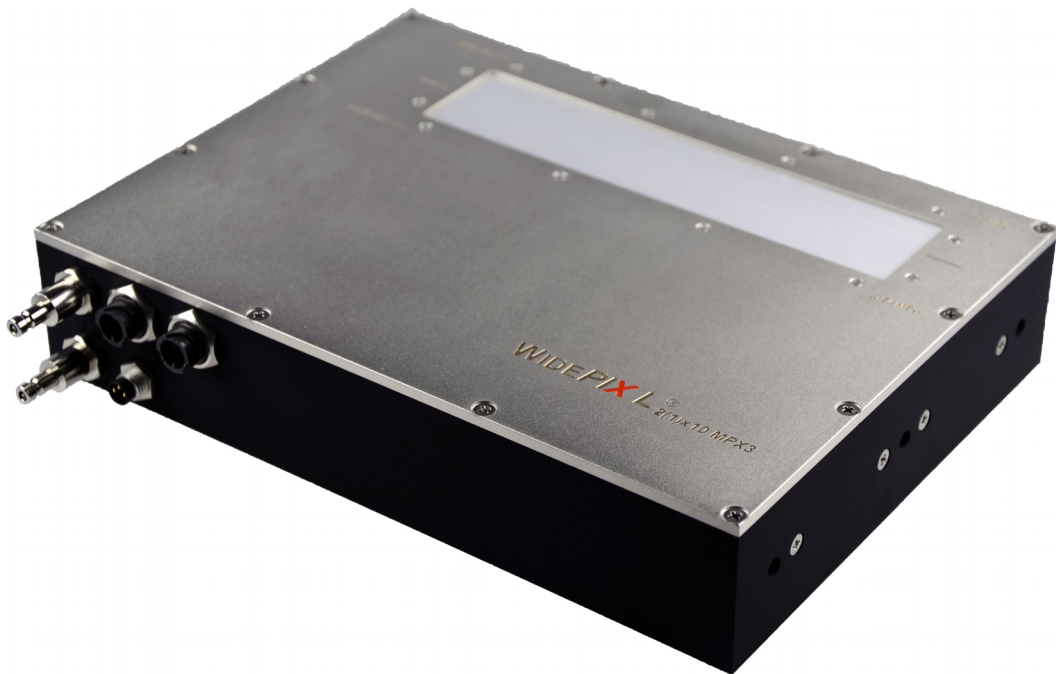
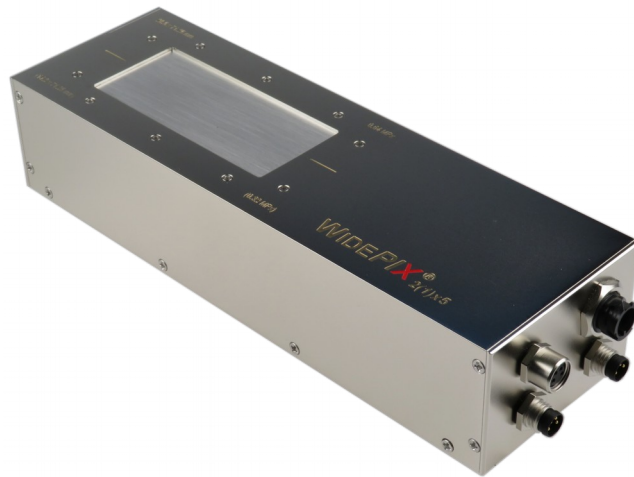


ADVACAM

Imaging the Unseen



WidePIX, WidePIX L MPX3 manual

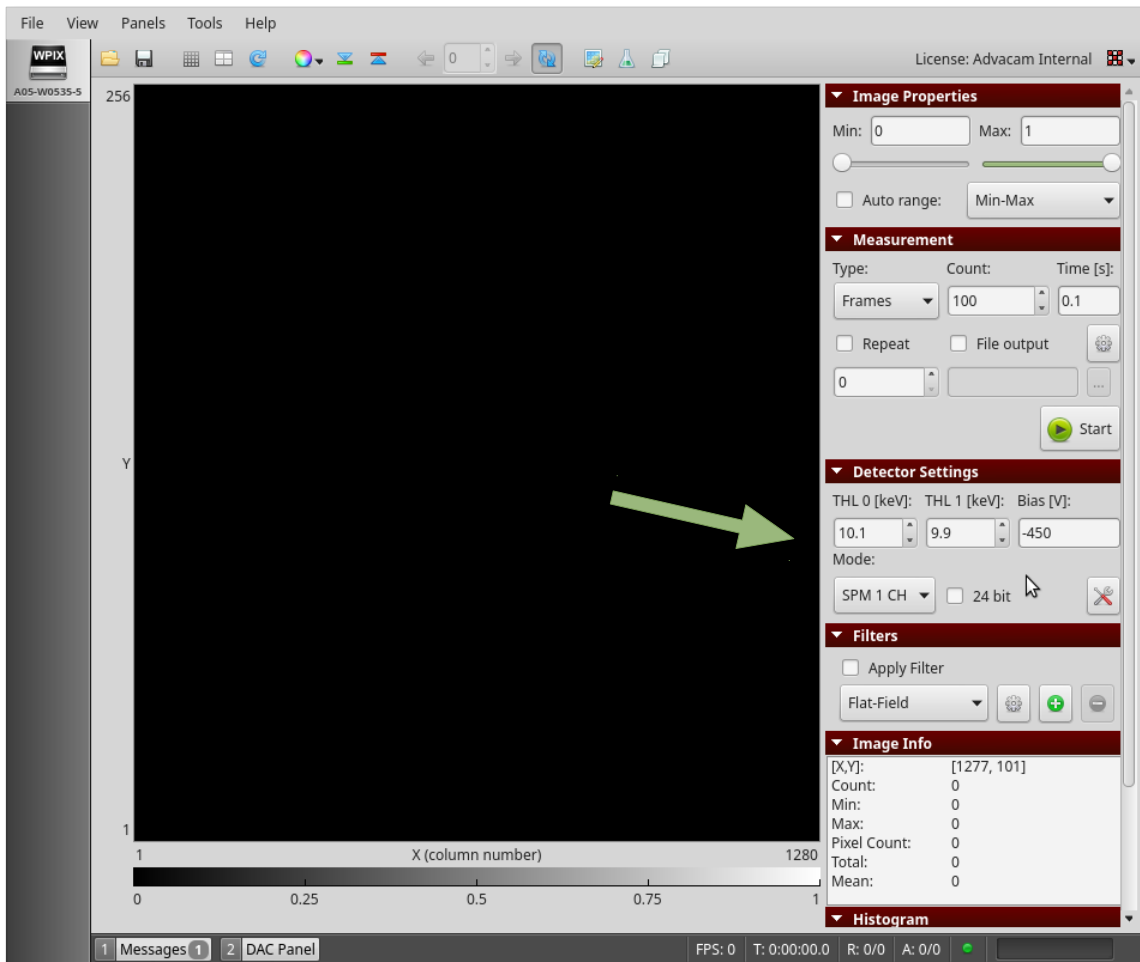
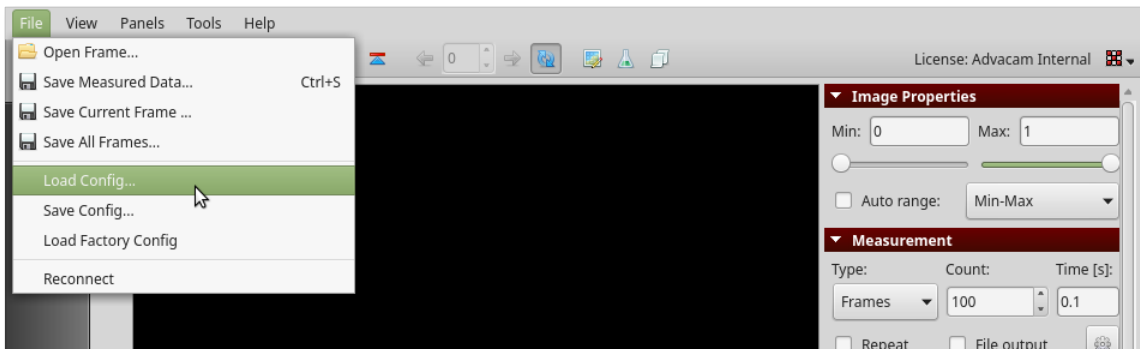


Content of package

- WidePIX / WidePIX L Medipix3 device
- USB 2.0 cable(s)
- +24 V DC adapter
- Quick couplings for water cooling
- USB memory stick with control software Pixet

Start guide

1. Connect the device to the water cooling system. Thermal stabilization to 20-25°C is strongly recommended.
2. Connect the device to the computer via USB cable(s).
3. Plug in the power adapter.
4. Connect the attached USB memory stick to the computer.
5. Install the device drivers:
 - Microsoft Windows: run *drivers/setup.exe* and follow the instructions.
 - macOS: run *drivers/D2xxHelper_v2.0.0.pkg*.
 - Linux: installation of any special drivers is not required.
6. Install the Pixet application:
 - Pixet for Windows is distributed as a single executable file for automatic installation. Run *setup.exe* and follow the instructions in the setup wizard.
 - Pixet for macOS system is distributed as a standard *dmg* file (disk image file). After mounting the *pixet.dmg* file a window with disk content will open. To install, move the *Pixet* folder to the Application folder.
 - Pixet for Linux system is distributed as a single *tar* file. To install, untar the file at a required location. The application is launched by executing the *pixet.sh* script.
7. Run Pixet application. An icon with ID of your device must appear in the left panel.
8. Default configuration of the connected device is loaded automatically. Configuration file contains default settings of the detector including calibration of energy thresholds to keV. Settings of thresholds in keV and bias voltage are shown in the *Detector Settings* panel when the configuration is properly loaded. The device is now ready for use. However, **it is advisable not to start any measurements until the thermal equilibrium is established (~ 20 minutes)**.
9. Last detector settings with all your modifications are stored locally on your computer when Pixet is closed. The settings will be loaded again when starting Pixet with the same device next time. The defaults can be restored at any time by loading the default configuration: Click *File – Load Config* in menu bar and choose the configuration file using system dialog window. It is located in the *Pixet/configs* folder and has *.xml* extension.





Understanding the Medipix3 chip operation

Comparison of Medipix and Timepix chips

- Timepix-based detectors allow both the photon counting and spectroscopic “time-over-threshold” measurement. Medipix-based detectors operate only in the photon counting mode. However, the radiation spectra can be measured using a threshold scan.
- Timepix-based detectors have single energy threshold. All energies below the set value are cut off. Devices are set to a minimal threshold above noise by default. This is typically 5 keV. The threshold can be adjusted by user in the counting mode.
- Medipix3 detectors have one or more adjustable energy thresholds. The number of thresholds varies according to the sensor pixel pitch and the mode of operation. The logic is the same as for Timepix-based detectors; all available thresholds cut off lower radiation energies. Minimum threshold is typically higher compared to Timepix-based devices and depends on additional settings.
- Unlike the Timepix-based detectors, the Medipix3 offers several operation modes for the counting measurement. The list of modes is described in the following section.

Overview of Medipix3 read-out chip operation

Each pixel of the Medipix3 (MPX3) chip has **two thresholds** and **two 12-bit counters**, which can be alternatively merged to one **24-bit counter**, providing enhanced dynamic range.

In principle, two main modes of operation are available:

1. **Single Pixel Mode (SPM)**: every pixel works independently of its neighbours, analogous to Timepix-based devices.
2. **Charge Summing Mode (CSM)**: two thresholds are used for the energy discrimination. The algorithm is as follows: the detected quantum of radiation generates an electric charge in the sensor. The charge is typically collected to two or more pixels and creates an electric signal in each pixel. The signal is compared to the first threshold in every pixel. Signals below the threshold are cut off (similar to the SPM). The signal/charge of 4 neighbouring pixels is reconstructed (summed) and assigned to the pixel with the largest charge deposition. The result is then compared to the second threshold, signals below the threshold are omitted.

The CSM suppresses the effect of charge sharing and the images are sharper in comparison to the SPM.

Both modes can be moreover operated in several **ranges** which define the minimal and maximal achievable threshold. Selection of the range affects also further properties, such as the energy resolution and stability (noise) of the detector. The range setting can be found in literature under the term “gain mode”.

Settings of WidePIX MPX3 device (55 μm pixel pitch)

Setting the operation mode and counter depth

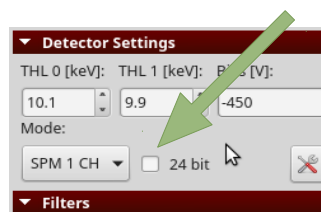
Mode of operation can be selected via drop-down list in the *Detector Settings* panel:

- **SPM 1 CH (Single Pixel Mode – one channel)**. One counter is in use. One energy threshold (energy channel) is available. Measurement output: one 12-bit or 24-bit image representing the number of events per pixel.
- **SPM 2 CH (Single Pixel Mode – two channels)**. Two counters are in use. Two energy thresholds (energy channels) are available. Measurement output: two 12-bit images representing the number of events per pixel.
- **CSM (Charge Summing Mode)**. Two energy thresholds are in use. Measurement output: one 12-bit or 24-bit image representing the number of events per pixel.

After changing the operation mode, values of the energy thresholds may change according to the respective energy calibration.



Counter depth is set to 12 bits by default. Check the checkbox in the *Detector Settings* panel for the 24-bit depth.

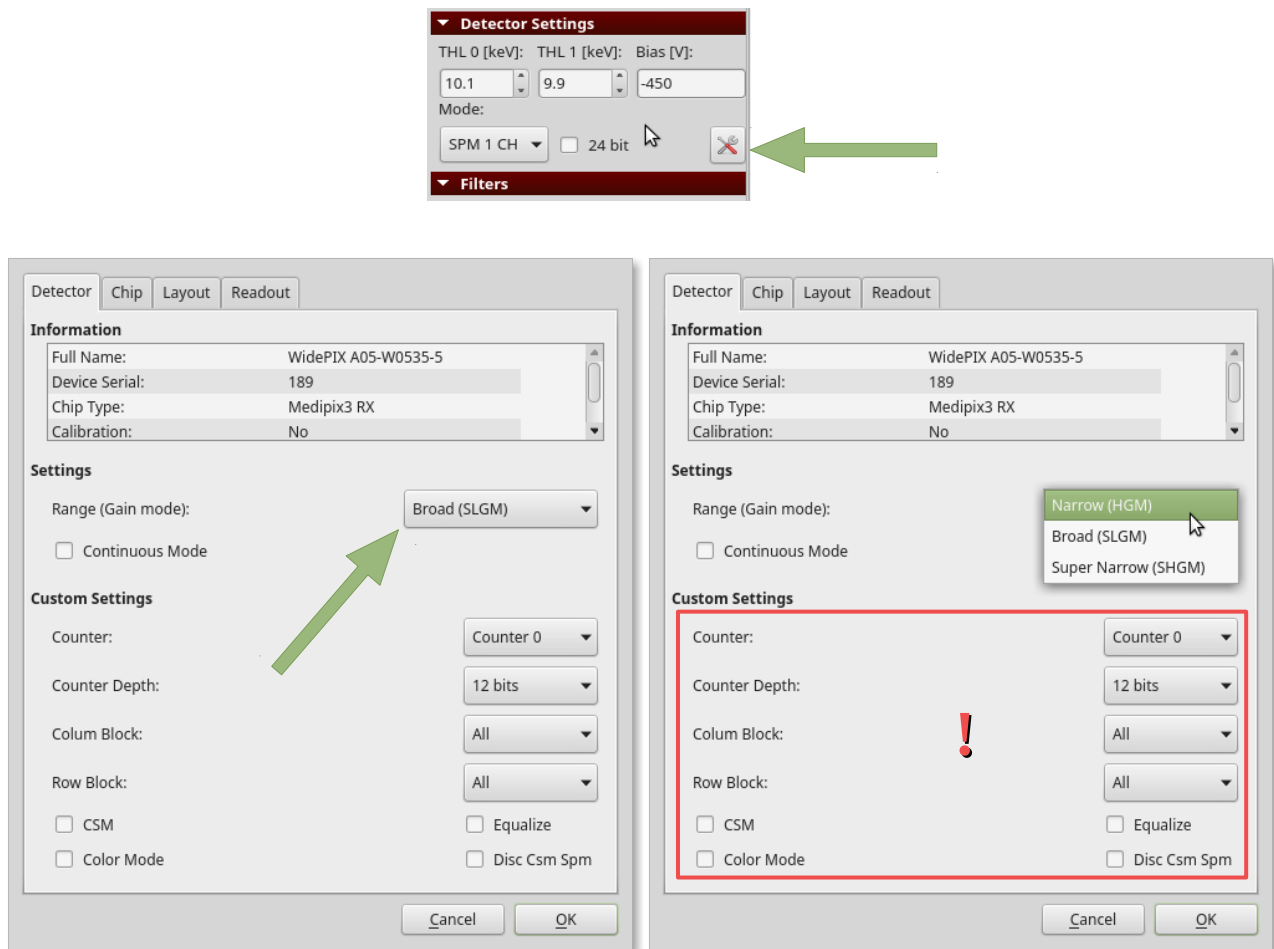


Setting the range - advanced

Click on the *More Detector Settings* button in the *Detector Settings* panel. New window will appear. Select the range in the drop-down list within the *Settings* section of the first *Detector* tab:

- **Broad** – the largest threshold range.
- **Narrow** – better energy resolution at lower energies.
- **Super Narrow** – very limited threshold range, the best energy resolution at lower energies, better signal-to-noise ratio.

Note: *Super Narrow* range is not available with silicon detectors.



Click **OK** to confirm the changes.

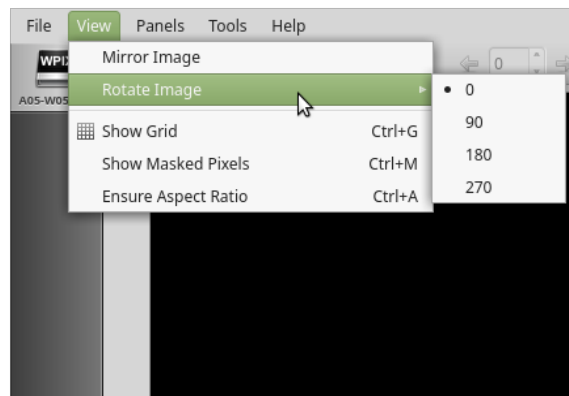
Note: the *Custom Settings* section is intended for expert users only. Any modification of *Custom Settings* section may lead to unpredictable behavior of the device!

Useful tips and how-tos

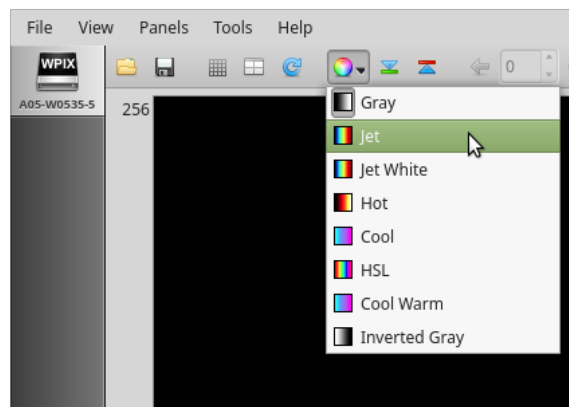
Pixet Pro is being developed in Advacam s.r.o. as desktop application for expert users. It implements full control of the Timepix- / Medipix-based detectors and it is used within manufacturing processes (testing, calibration, ...) as well as during the preceding development phase of the devices. Since the application is very powerful, inexperienced user could set the device to non-functioning state. Recovery from such case is loading the factory settings shipped with the detector.

Here are several tips for more effective and comfortable use:

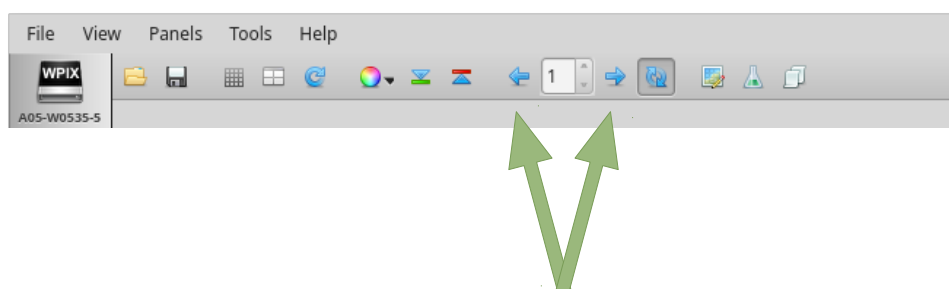
- Composition of panels on the right side of the Pixet window can be configured in *Panels* in menu bar.
- Orientation of the image (rotation, mirroring) can be customized in *View* drop-down list in menu bar.



- To keep the aspect ratio of the image click on *View – Ensure Aspect Ratio* in menu bar.
- Default colormap is gray. Colormap can be selected via drop-down list under the multicolored icon located in main toolbar.

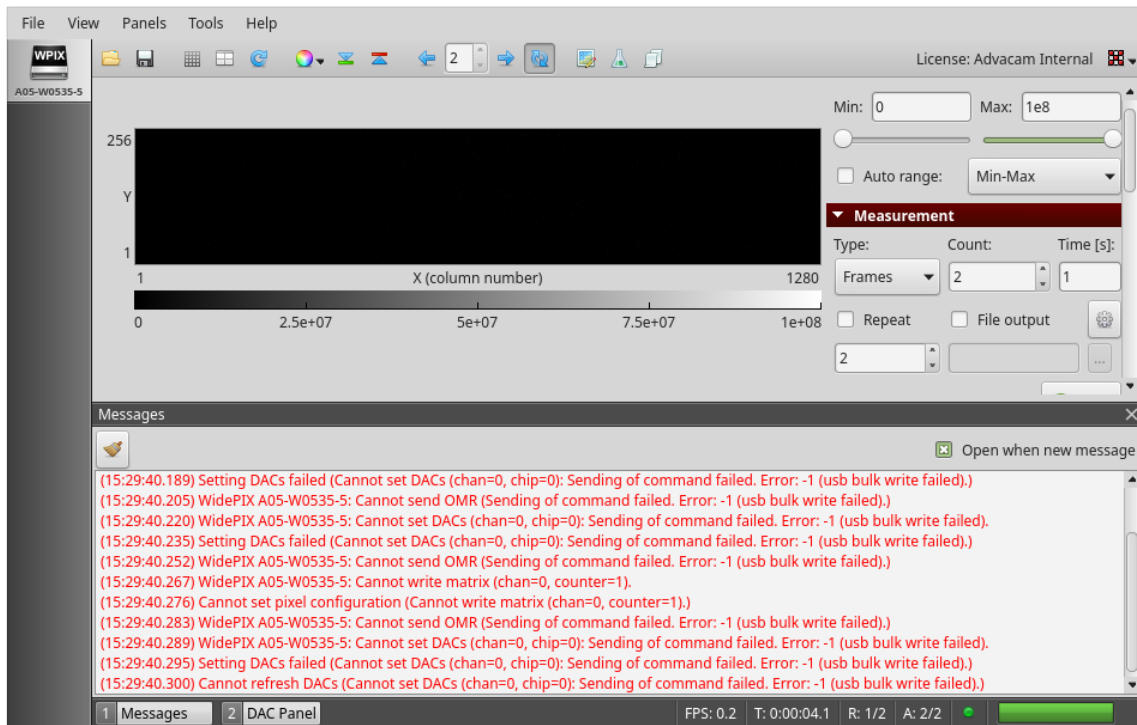


- *Image Properties* panel allows to adjust brightness and contrast of the displayed images by setting the range to be displayed. *Auto range* option provides automatic adjustment.
- *Advanced Image Properties* panel allows to set **gamma correction** for better visibility of features within measured sample.
- Pixet allows opening and showing previously saved images by drag and drop into image area of the Pixet window. When multiple images are drag and dropped, one can browse them using blue arrows in the main toolbar.





- Images can be zoomed by holding the left mouse button in the frame, dragging the mouse to create a selection rectangle and releasing the mouse button. To restore the original frame size, double click on the image.
- Application output including error messages are shown in *Messages* panel.



- In case of hardware disconnection, the device can be reconnected by clicking *File – Reconnect* in menu bar without restarting Pixet application.

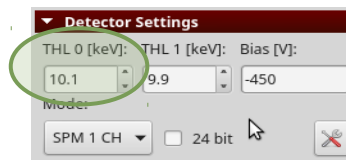


Practical examples of measurements

1. Measurement in SPM using one threshold

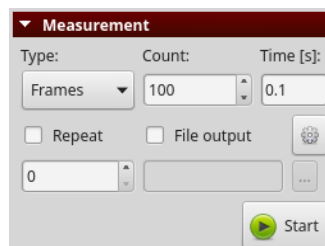
Setting of the detector on *Detector Settings* panel

- Set the device to *SPM 1 CH* operation mode as described above.
- Switch on / off the 24-bit counter depth as described above (optional).
- Set first threshold *THL 0 [keV]* to desired value. Second threshold *THL 1 [keV]* is not in use for this operation mode.



Controlling the measurement parameters via *Measurement* panel

- Select type of measurement in *Type* drop-down list. There are three options:
 - For single acquisition select *Frames* and set parameter *Count* to 1.
 - *Integral* – several acquisitions are added to one frame. Number of acquisitions to be added is defined by parameter *Count*.
 - *Test Pulses* – for service use only.
- Set the exposure time of individual frame acquisitions in seconds using *Time [s]* text box.
- Checking the *Repeat* checkbox and setting the number of repetitions using the text box underneath will cause repeating the defined measurement several times. Setting the number of repetitions to zero value means “repeat forever”. If the *Repeat* checkbox is unchecked, the number of repetitions is not in use.



Note: In case of combining *Repeat* and *Frames*, it is advisable to set the *Count* parameter to value greater than 1, especially for acquisition times shorter than 1 s. This prevents from unwanted increase of measurement dead time.

Starting the measurement

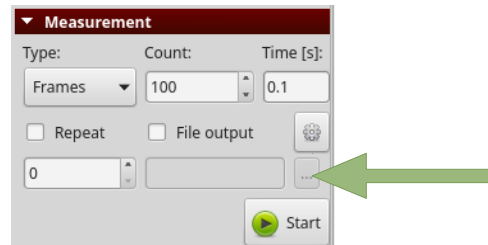
Start / stop the measurement using *Start / Stop* button on the *Measurement* panel. Progress of the measurement is shown in the status bar at the bottom of the window.

Once the measurement is finished, the measured frame is shown in the image preview area of the Pixet window.



Automatic saving of measured data

Check *File output* in *Measurement panel* for automatic saving. Then click on the button with three dots. A system dialog window will appear to Select the target destination and filename. Confirm it by clicking the *Save* button. Measured data are saved automatically during the measurement. A warning dialog will appear if the file name and destination is used for another measurement.



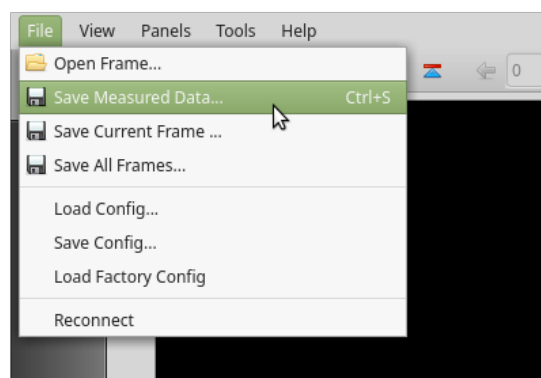
Two files are saved by default to each frame:

- data file (.txt)
- description file (.dsc) which contains information about the device, used configuration, measurement settings, etc.

Manual saving of measured data

Click on *Save Measured Data* option in *View* drop-down list in menu bar. A system dialog window will appear. Select the target destination and filename and confirm by clicking the *Save* button. All frames within the sequence defined by the *Count* parameter are saved.

Save Current Frame option in *View* drop-down list in menu bar will save the last frame only. Option *Save All Frames* is similar to the *Save Measured Data* in this case.



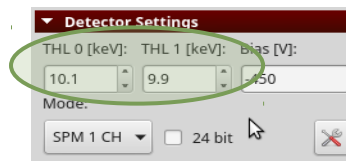
2. Measurement in SPM using two thresholds

Setup of the detector in *Detector Settings* panel

- Set the device to *SPM 2 CH* operation mode as described above.
- 24-bit counter depth is not available.



- Set both thresholds $THL\ 0$ [keV], $THL\ 1$ [keV] to desired values. Second threshold should be higher than the first threshold.



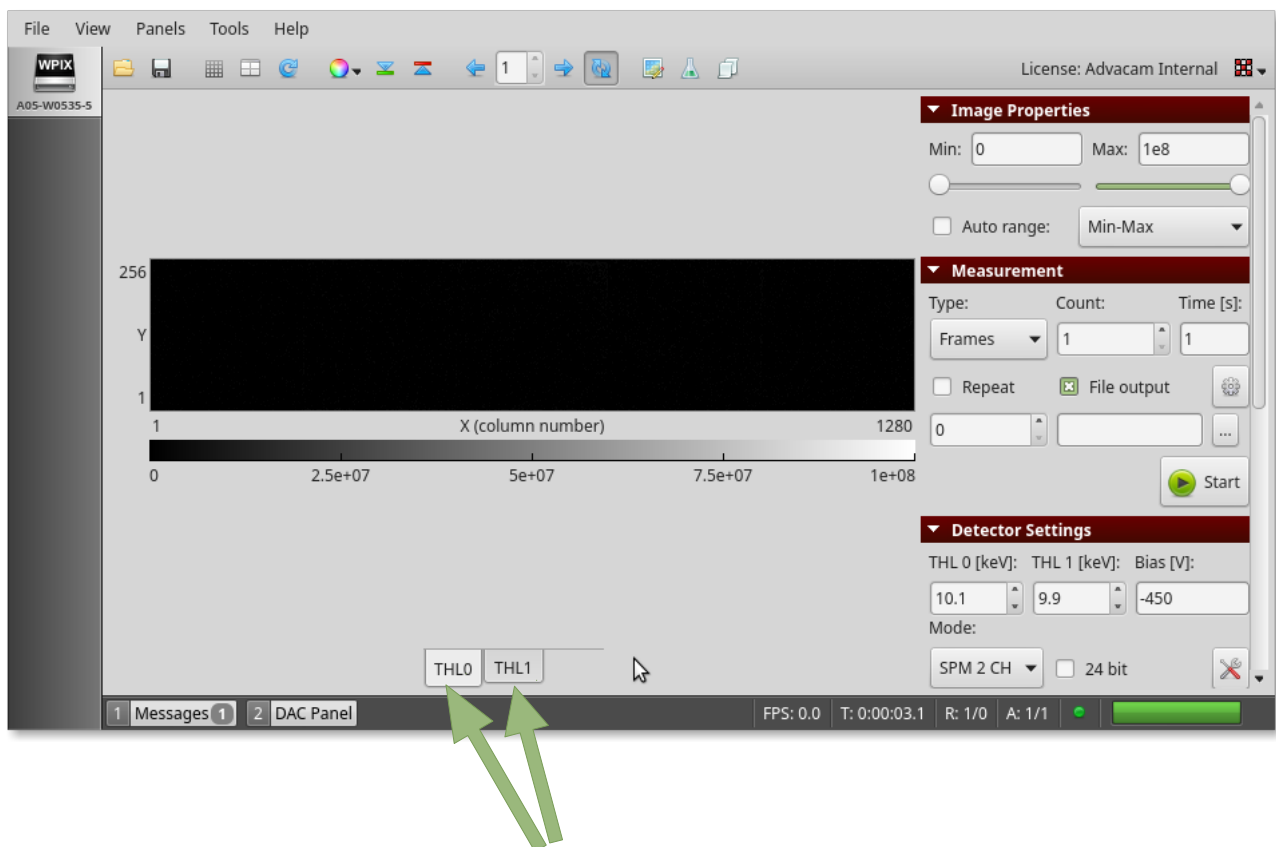
Controlling the measurement parameters via *Measurement* panel

See example 1.

Starting the measurement

See example 1.

Once the measurement is finished, the measured frames are shown in the image preview area of the Pixet window. Use buttons at the image area bottom to switch between the energy channels.



Automatic saving of measured data

See example 1.

Six files are saved by default:



- data file (.txt) for first channel with ending “_THL0”
- description file (.dsc) for first channel with ending “_THL0”
- data file (.txt) for second channel with ending “_THL1”
- description file (.dsc) for second channel with ending “_THL1”
- data file (.txt) combining both channels – for service use.
- description file (.dsc) combining both channels – for service use.

How to save measured data manually

Click *Save Measured Data* option in *View* drop-down list in the menu bar. A system dialog window will appear. Select the target destination and filename and confirm it by clicking the *Save* button. All frames within the sequence defined by the *Count* parameter are saved for both channels.

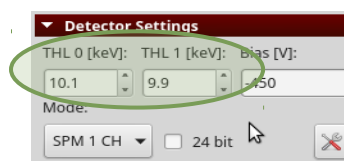
Click *Save All Frames* to save the entire frame sequence of the selected channel only.

Click *Save Current Frame* option in *View* drop-down list in menu bar to save the last frame of the selected channel only.

3. Measurement in CSM

Setting of the detector on *Detector Settings* panel

- Set the device to *CSM* operation mode as described above.
- Switch on / off the 24-bit counter depth as described above (optional).
- Set both thresholds *THL 0 [keV]*, *THL 1 [keV]* to desired values. Second threshold should be higher than first threshold.



Controlling the measurement parameters via *Measurement* panel

See example 1.

Starting the measurement

See example 1.

Automatic saving of measured data

See example 1.

How to save measured data manually

See example 1.

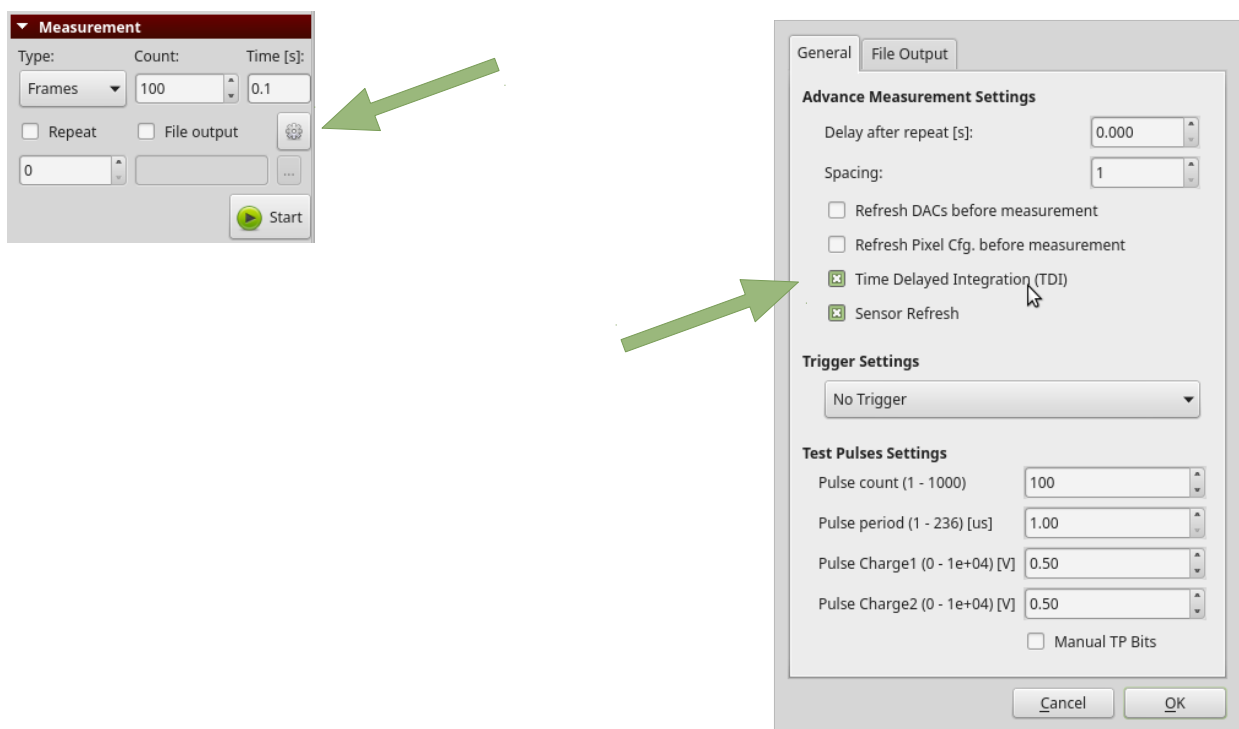


4. Measurement in Time Delay Integration regime

The time delay integration (TDI) is implemented for **WidePIX 1x5**, **WidePIX L 1xN** (N = 5, 10, 15, ...) devices. TDI can be used for continuous scanning where for example samples move on a conveyor belt along the detector.

Setting up the Time Delay Integration regime

To switch on / off this functionality click on *More Measurement Settings* button in the Measurement panel. New window will appear. Then check / uncheck *Time Delayed Integration (TDI)* checkbox in the *Advanced Measurement Settings* section on the first tab *General*. Confirm the change by clicking *OK*.



All operation modes, bit depths and ranges of static measurement (as described in previous section) are implemented also in TDI.

Alignment of the experiment

Sample to be measured has to move along the detector. Movement of the sample with respect to the WidePIX device must be in the sense from the top to the image bottom (i.e. towards the device readout peripheries; by default the image in Pixet is oriented with peripheries at the bottom).

Basic settings

Set the operation mode, counter depth and energy threshold(s) as desired. Switch on the TDI regime as described above.



Measurement panel

- Set the *Type* of measurement to *Frames*.
- Set number of frames into *Count*.
- Enable repeating and set number of repeats.
- Set acquisition time *Time [s]* corresponding to the movement of the sample by chip size (dead time for the chip read-out should be included). The chip size is $256 \times 0.055 = 14.08$ mm. Hence, the exposure time corresponds to the speed the sample moves along this distance. To achieve a perfect synchronization the time can be optimized by evaluation of the object sharpness.

Automatic saving of measured data

See example 1.

How to save measured data manually

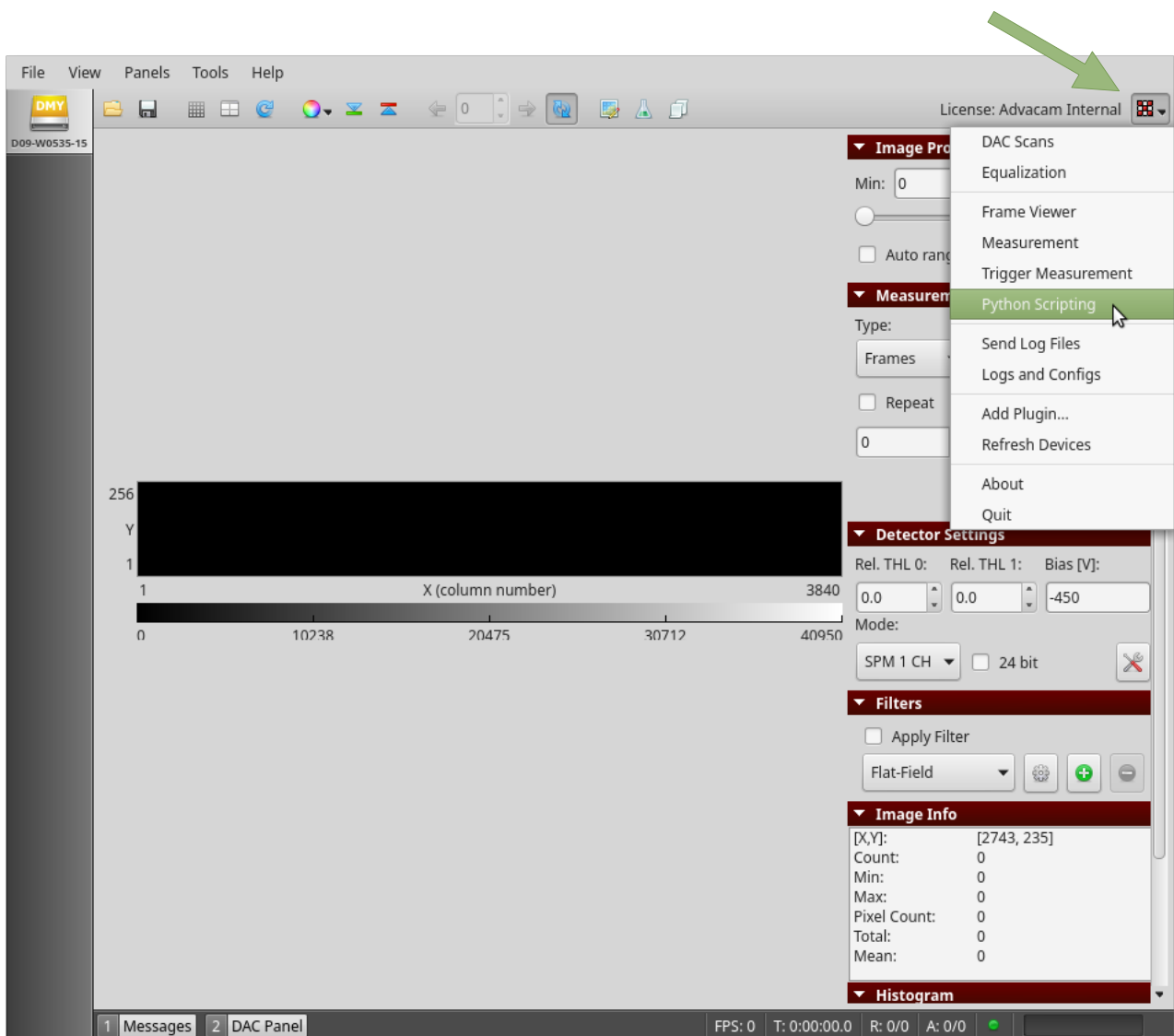
See example 1.

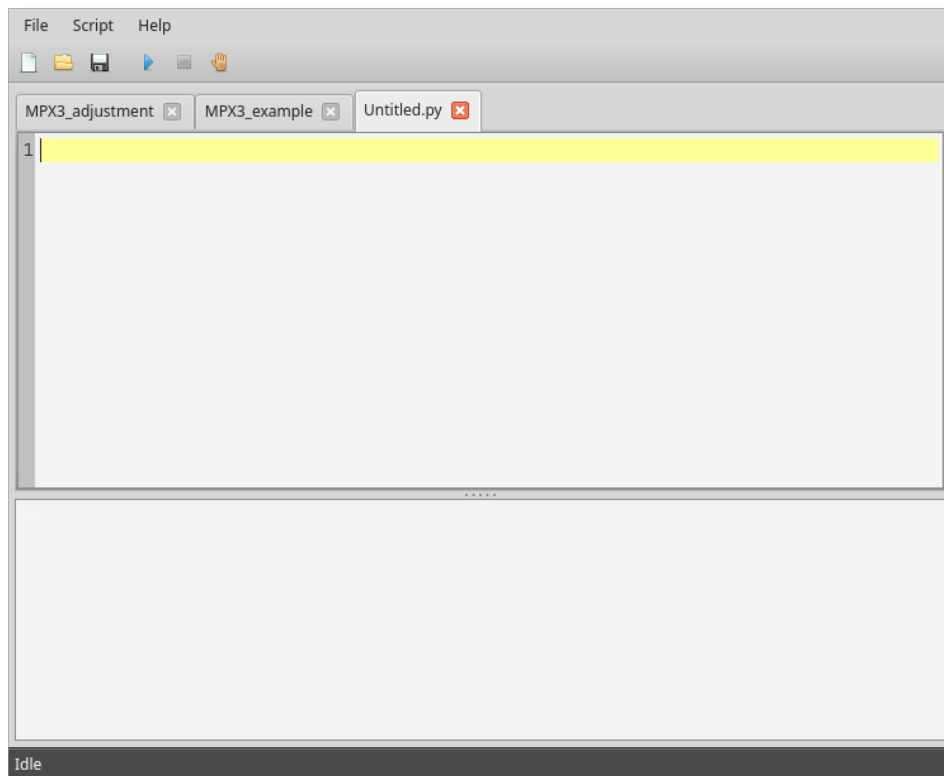


Advanced control using Python Scripting plugin

Python Scripting plugin allows the user to perform complex measurements controlling the detectors automatically via Python commands and scripts. The *Python Scripting* embeds a full python 2.7 interpreter including the standard python libraries. All standard functionality of python is therefore accessible. Please refer to www.python.org or www.learnpython.org for more information about Python programming language.

Click on the icon on the right edge of the main toolbar to start the *Python Scripting* plugin. Choose *Python Scripting* from the list. A new window with simple editor will open. The bottom part of the plugin window contains a python console, where python commands can be run one by one with immediate output. The console also contains the output of executed python script.





The Pixet API (Application Programming Interface) is accessible in the scripts via a **pixet** variable. This variable represents the **IPixet** object that provides all the necessary methods to get information about all connected devices, log messages to log file, access the Pixet menu, etc. A list of all available objects, methods and constants of the Pixet API can be displayed by clicking *Help – Function List...* in the main menu of the *Python Scripting* window.

1. Sample script #1

Detector settings (operation mode, counter depth, range, threshold), simple acquisition

```
# get list of all connected Medipix3 devices
devices = pixet.devicesByType(pixet.PX_DEVTYPE_MPX3)

# get first device from list
dev = devices[0] # returns IDevMpx3 object

# set operation mode
dev.setOperationMode(pixet.PX_MPX3_OPM_SPM_1CH)
# SPM 1 CH: pixet.PX_MPX3_OPM_SPM_1CH (0)
# SPM 2 CH: pixet.PX_MPX3_OPM_SPM_2CH (1)
```




```
# CSM:          pixet.PX_MPX3_OPM_CSM (2)

# get operation mode
print('Operation mode: ' + str(dev.operationMode()))
```



```

# set counter depth
dev.setCounterDepth(pixet.PX_MPX3_CNTD_24B)
# 12 bits:  pixet.PX_MPX3_CNTD_12B (2)
# 24 bits:  pixet.PX_MPX3_CNTD_24B (3)

# get counter depth
print('Counter depth: ' + str(dev.counterDepth()))

# set range
dev.setGain(pixet.PX_MPX3_GAIN_SUPERHIGH)
# Super Narrow: pixet.PX_MPX3_GAIN_SUPERHIGH (0)
# Narrow:       pixet.PX_MPX3_GAIN_HIGH (1)
# Broad:        pixet.PX_MPX3_GAIN_SUPERLOW (3)

# set threshold
th_index = pixet.PX_MPX3_TH0 # index of threshold to be changed
# THL 0: pixet.PX_MPX3_TH0 (0)
# THL 1: pixet.PX_MPX3_TH1 (1)
chip = 4 # chip index (chips are counted from 0!)
# chip #1: 0
# chip #5: 4
# all chips: pixet.PX_CHIP_ALL (-1)
th_energy = 30 # new value of threshold in keV
dev.setThreshold(chip, th_index, th_energy, pixet.PX_THLFLG_ENERGY)

# acquisition
acqCount = 1 # number of acquisitions
acqTime = 10 # time of acquisition in seconds
dev.doSimpleAcquisition(acqCount, acqTime, pixet.PX_FTYPE_NONE, '')

# get last acquired image
frame = dev.lastAcqFrameRefInc()
data = frame.data()

```

2. Sample script #2

Integral acquisition, saving the data

```

# get first device from list of all connected Medipix3 devices
dev = pixet.devicesByType(pixet.PX_DEVTYPE_MPX3)[0]

# set operation mode
dev.setOperationMode(pixet.PX_MPX3_OPM_SPM_2CH)

```



```
# set acquisition parameters
acqCount = 10          # number of acquisitions for integral measurement
acqTime = 0.1         # time of one acquisition
fileName = './test/image.txt'

# integral acquisition, saving
dev.doSimpleIntegralAcquisition(acqCount, acqTime, pixet.PX_FTYPE_AUTODETECT,
    fileName) # data are automatically saved
```

3. Sample script #3

Threshold scan

```
# get first device from list of all connected Medipix3 devices
dev = pixet.devicesByType(pixet.PX_DEVTYPE_MPX3)[0]

# set operation mode
dev.setOperationMode(pixet.PX_MPX3_OPM_CSM)

# set acquisition parameters
th = pixet.PX_MPX3_TH1 # index of threshold to be changed
ths = range(10,45,5)   # thresholds in keV
acqCounts = [1 for number in ths]
acqTimes = [0.1 for number in ths]
output = './test_'    # destination path

# threshold scan
for i in range(len(ths)):
    print('TH: {}'.format(ths[i]))
    dev.setThreshold(pixet.PX_CHIP_ALL, th, ths[i], pixet.PX_THLFLG_ENERGY)

    fileName = output + str(ths[i]).zfill(3) + 'keV.txt'

    dev.doSimpleIntegralAcquisition(acqCounts[i], acqTimes[i],
    pixet.PX_FTYPE_AUTODETECT, fileName)
```