XGLAB
X and Gamma Ray Electronics

XGLab S.R.L.
Via Conte Rosso 23, I-20134 Milano (Italy)
ph: +39 02 49660460
VAT and Tax Payer #: 06557660963
Capitale Sociale 50.000 euro I.V., R.E.A. MI-1899304
Direction and co-ordination: Bruker Italia S.r.l.

DANTE
User Manual

Revision: 2.7
Date: July 26th, 2021

Table of Contents

Safety norms and instructions

The following general precautions must always be observed in order to ensure personal safety of the user and to prevent any damage to the DANTE and to any other device or equipment connected to it. The manufacturer cannot be considered responsible for any damage on injury caused by using the DANTE in a manner not compliant with the use described in this manual.

General

The DANTE acquisition system is compliant with European norms in terms of safety issues related to laboratory environment.

Electrical

Always connect the GND terminal of the DANTE to earth potential with a low impedance cable.

The DANTE is equipped with digital and analog inputs; under no circumstances shall the voltage applied to those inputs exceed ±5 V.

The DANTE is intended to be operated with a single DC voltage supply; all the voltages necessary for operation are generated internally starting from such single external power source.

Risk of electric shock

Please always use the AC/DC adapter originally supplied with the DANTE at the time of purchase, whose characteristics are summarized in the table below. Using an incorrect power adapter may cause permanent damage to the DANTE and to any device connected to it. Such damages are not covered by warranty.

Power supply characteristics

	1-channel DANTE	8-channel DANTE
Input voltage	110-240 VAC, 50-60 Hz	110-240 VAC, 50-60 Hz
Input max. current	0.8 A	1.1 A
Output voltage	+12 V DC	+ 24 V DC
Output max. current	3.0 A	2.01 A

Environmental conditions

Always verify the mechanical stability of the setup to prevent accidental fallings.

Operating the DANTE outside of its operating range may cause permanent damage to the DANTE itself and to any other device connected to it.

Operating conditions: 0°C to +50°C, 10 to 90% humidity, non-condensing.

Typical Storage and Shipping: -20°C to +85°C, 10 to 90% humidity, non-condensing.

Risk of overheating

Do not cover any holes and do not obstruct any fan openings, as doing this may cause overheating of internal components. Keep a minimum clearance of 10 cm between any openings and other objects.

Instrument inspection and maintenance

The DANTE does not need any periodic mantainance and has no user-serviceable parts. Check frequently for fan obstructions and remove any dust that may accumulate over time preventing the fans from spinning correctly. In case of any suspected damage, do not attempt to open the device at any time; instead, contact the vendor or the manufacturer for assistance. Opening the device to access to internal components will void your warranty.

Risk of short circuit

In order to prevent the risk of short-circuits, verify the integrity of DC supply cables and of the GND cable every 6 months, or any time the DANTE is moved to a new location.

Cleaning

Clean the outside of the DANTE using a soft, dry, lint-free dust cloth. Do not use solvents for cleaning, as they can damage the painting and front/back panel labeling.

1. Overview

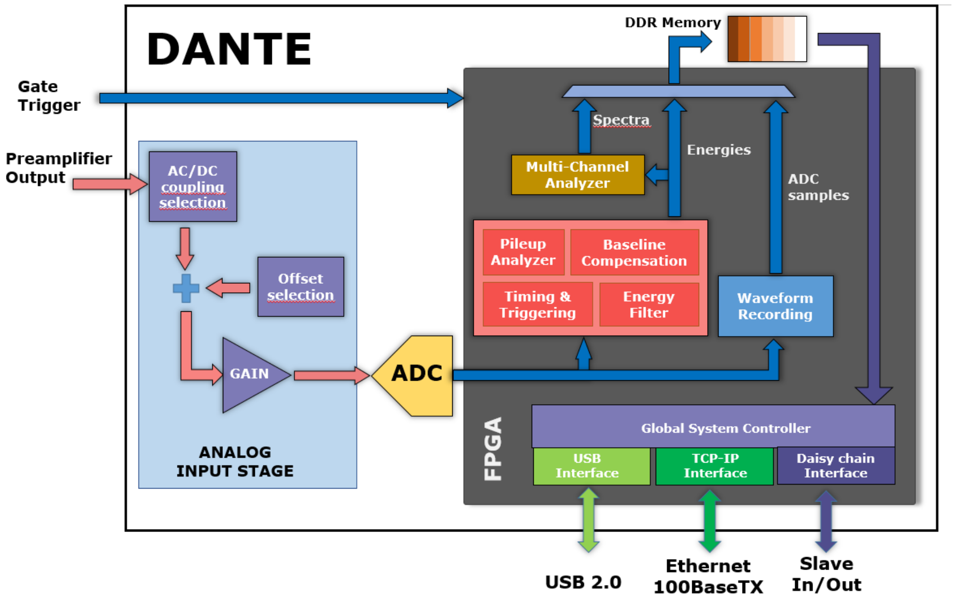


Figure 1.1: Main DANTE DPP scheme

DANTE is a versatile digital acquisition system specifically designed for X-ray spectroscopy applications. Designed to meet the demanding requirements of modern Synchrotrons and X-ray Laboratories, it enables light elements measurement with outstanding low-energy resolution performance as well as high-rate applications with fast peaking time and best-in-class pile-up rejection.

DANTE 1CH: single channel solution

FEATURE SUMMARY	
Box size and weight	6.5cm x 11cm x 4cm, 0.4Kg
Power dissipation	~2.5W (12V input voltage)[1]
Analog/digital inputs	1 LEMO analog input 1 LEMO digital input TTL/CMOS3.3 compatible
Scalability	Not available
Interface	USB 2.0 | TCP/IP 100BaseTX

[1] **Power supply:** DANTE is delivered with the commercial AC/DC adapter VEL12US120 from XP-Power

DANTE 8 CH: multi channels solution

FEATURE SUMMARY	
Box size and weight	20cm x 11cm x 11cm, 1.7Kg
Power dissipation	~25W (24V input voltage)[1]
Analog/digital inputs	8 SMA analog input 1 SMA digital input TTL/CMOS3.3 compatible
Scalability	Daisy-chain. Synchronization among channels
Interface	USB 2.0 | TCP/IP 100BaseTX

[1] **Power supply:** DANTE is delivered with a customized AC/DC power supply based on AED36US24 from XP Power.

The DANTE DPP box is intrinsically made up of different DANTE DPP boards connected in a daisy-chain fashion.

Figure 1.2: Example of multiple DANTE-8ch connection

Furthermore, the DANTE DPP box can be connected in daisy-chain itself by stacking different boxes using the top and bottom panel DSUB25 connectors. Only one box needs to be connected to the PC (either via USB or within the LAN using the Ethernet connector) and that box will act as the master of the chain: it routes configuration commands to the other boxes and receives the spectrum data from all the channels.

In case of high data throughput acquisitions (e.g. map or listmode), it can be useful to use separate USB 2.0 (or ethernet) connection for each box even if they are connected in daisy-chain. This allows higher communication bandwidth while mantaining the boxes synchronized, which can be extremely useful for time-stamping single events on different detectors.

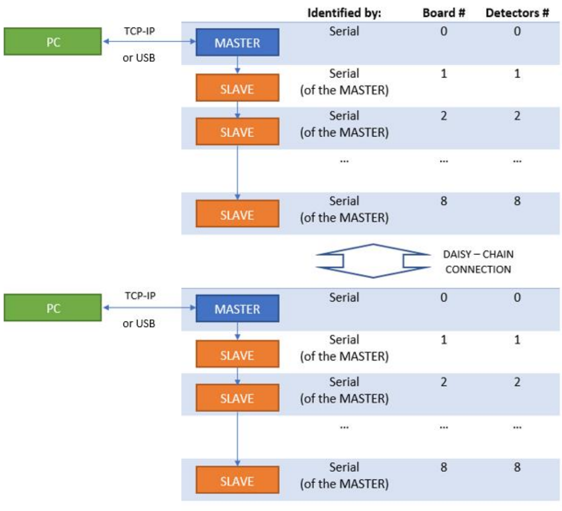


Figure 1.3: Daisy-Chain configuration - Multiple connections

2. Specifications

2.1. Overview

Parameter	Conditions	Value
Analog input range	AC or DC coupling	3 $V_{pk\text{-}to\text{-}pk}$
Offset	SW selectable	±1.5 V
Analog Gain	with 50 ohm preamp output	x1
Digital Gain		0.01 - 5
Input impedance	DC coupling	1 or 10 kOhm
Decay time	AC coupling	2 or 22 μs
Digital input	SW selectable as gating or trigger	CMOS-TTL compatible
Peaking time	Fixed trapezoidal filter High-rate (optional)	32ns, 64ns, 96ns, … 16 μs (step of 32ns) Peak time range: 32 ns – 4 μs
Flat-top	SW selectable in step of 32 ns	32 ns - 0.48 μs
Energy Range	Preamp gain =5 mV/keV Digital Gain = 1	0.100 keV – 40.00 keV
OCR vs. ICR	Peak Time = 32 ns	1.8 Mcps @ ICR 5 Mcps
ICR linearity	Fixed Trapezoidal Filter, Dead-time < 70% High-rate, Dead-time < 70%	3% 7 %
FWHM[1]	Peak Time = 64 ns Peak Time = 96 ns Peak Time = 1 μs	<160 eV @ 6 keV < 140 eV @ 6 keV < 125 eV @ 6 keV
FWHM stability	ICR = up to 1 Mcps	±5eV @ 6 keV
Peak position stability	ICR = up to 1 Mcps	<5eV @ 6 keV
Time Resolution τ (Pile-up rejection)	Fast Filter Peak Time = 8 ns	95 ns
Spectrum bins		1024, 2048, 4096
Waveform acquisition	62.5 MHz, 16-bit	Uninterrupted up to 0.5 s
Mapping mode	Spectra are switched automatically after a configurable interval or with a trigger input.	Down to 1 ms/spectrum (No dead time)
List mode	$E_1, E_2, \dots E_i$ $t_1, t_2, \dots t_3$	16-bit resolution 8 ns resolution

[1] **Test Conditions:** Detector SDD 30 mm², CUBE ASIC, preamplifier gain 7mV/keV, Temp = -35 °C, Flattop = 160 ns, ICR = 20 kcps, Irradiation source = ^{55}Fe.

2.2. AC-coupled, DC-coupled input

DANTE DPP features a configurable input front-end allowing both AC- and DC-coupling in order to be compatibile with different preamplifier dynamics and both continuos and pulsed reset strategies. AC coupling is mainly used for detectors with input dynamics larger than $3V_{PP}$.

Input config	Dynamic Input Resistance	Time-constant
DC high impedance	10 kOhm	-
DC low impedance	1 kOhm	-
AC slow	10 kOhm	22 µs
AC fast	1 kOhm	2 µs

2.3. API

Parameter	Conditions	Value
SW library	Windows	C++ library for x64 and x86 systems, Python 2.7 and Python 3.7, Labview-2013 (for Vista, 7, 8, 8.1, 10)
	Linux	C++ library x64 system, Python 2.7 Linux 64 bit with gcc version 4.4.7 or newer
Driver	Windows	EPICS
	Linux	EPICS, TANGO

DANTE device can be controlled with a flexible c++ based library compatible with both Windows and Linux operative systems. For higher compatibility, the library offers also python and LabView compatibility. Please consult the library manual for further details about compatibility.

Since the device ethernet communication is based on TCP/IP standard, DANTE can be also controlled without using any library but with direct TCP/IP commands

3. Installation

Please REFER to the following figures to perform the connections required for correctly operating the DANTE.

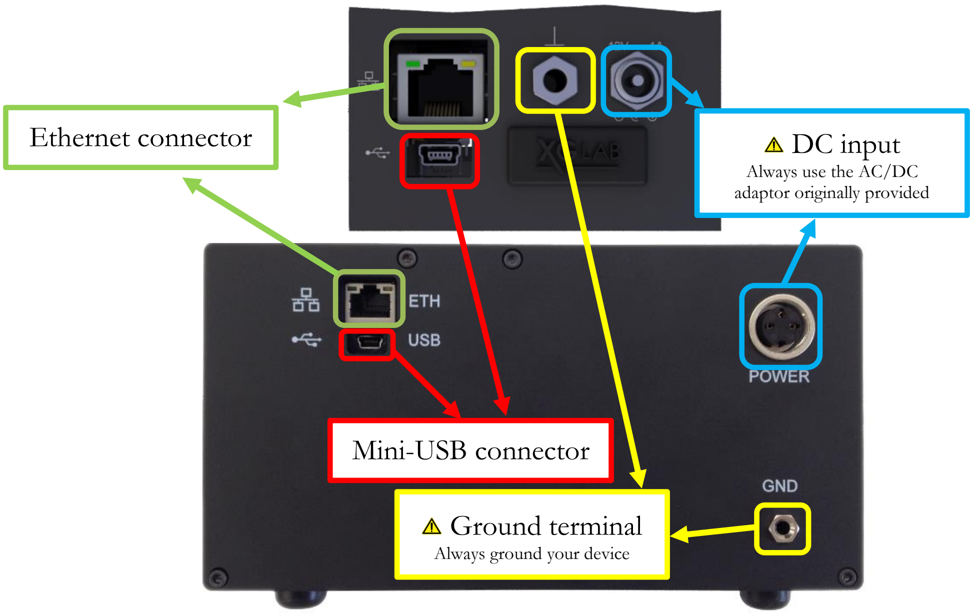


Figure 3.1: Dante back panel and connections (top: 1-channel; bottom: 8-channel)

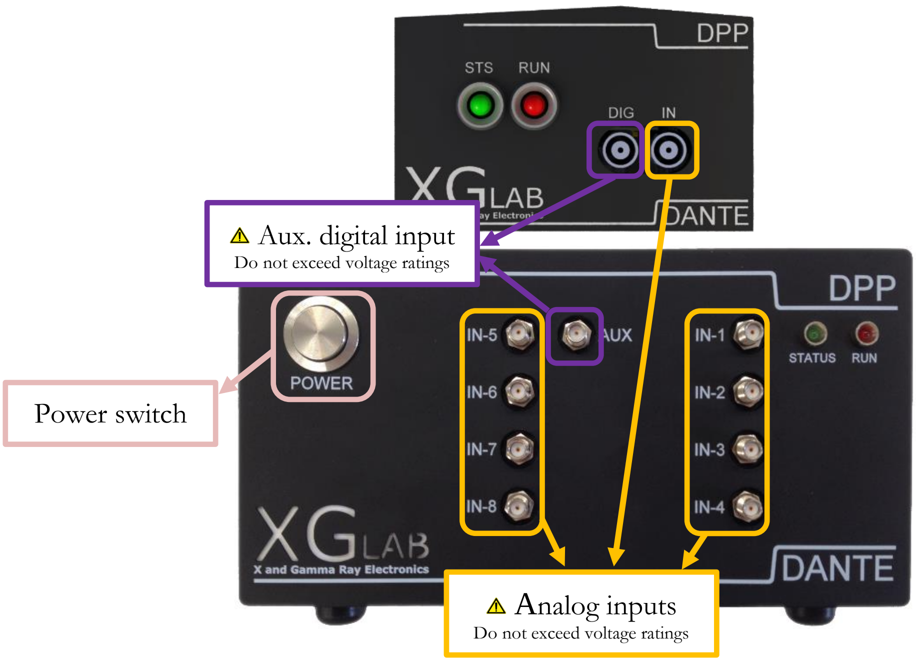


Figure 3.2: Dante front panel (top: 1-channel; bottom: 8-channel)

3.1. Hardware

Ground the device first, by connecting the ground connector marked with the GND symbol to a solid earth connection with a low-impedance cable. This connection is important both for reducing the effects of a potential electrostatic discharge and for minimizing the effects of electromagnetic interference.

Then, connect the device to a host PC either via the Ethernet connector or via the USB port, both present at the back of the device; finally, connect the desired analog and digital inputs to the SMA or LEMO connectors at the front of the DANTE. Once all connections are complete, connect the AC/DC power adapter (whose characteristics are described in the "Safety norms and instructions" section at the beginning of this document) at the back of the device, and turn on the power switch on the front panel (only for the 8-channel DANTE). The device is now ready to operate.

3.2. Software library and DANTE Acquisition Software

All the required software necessary to operate the device can be downloaded from the manufacturer website.

The software is available at the following link: https://www.xglab.it/dante-private-page/.

Registration is required in order to obtain acess to the content; if already registered, please insert your credentials at the following link: https://www.xglab.it/login/.

If not already registered, a new account should be created. Enter the "Sign-up" procedure at the following link: https://www.xglab.it/login/. After inserting your details, wait for an e-mail confirming the request approval; after being approved, log-in to the website and download the software from the Dante private page.

The distributable package contains an acquisition software (Windows only) and libraries (Windows and Linux) for directly interfacing to the device, together with examples, drivers and device firmwares.

Please refer to the Library API manual for a detailed description of the software library. A complete description of the acquisition software is exposed in Chapter 5, toghether with details of the DANTE operating modes. Please refer to the Examples folder as a starting point for writing your own application; examples are given in different programming languages (C++, Labview and Python), and a test Matlab GUI is also available.

4. Firmwares

DANTE can be used with two separate firmwares which target different acquisition performances:

- **Low-energy fw**: based on standard trapezoidal filtering and optimized for low-energy detection. Compatible with both pulsed reset and continuous reset strategies.
- **High-rate fw**: based on variable energy filter peaking time and optimized for best comprimise between OCR and energy resolution. Compatible only with pulsed reset strategy.

4.1. Low-energy firmware

Low energy firmware is based on standard trapezoidal filtering with a fixed peaking-time and flat-top. Common features are:

- Energy resolution mainly dependent on peaking-time duration.
- Stable energy resolution at different ICR.
- OCR performances directly related to the peaking-time duration.

In addition to the above common features, the XGLab low-energy firmware has been equipped with an energy threshold, which is less sentive to noise compared to standard and common fast-filter thresholds. This allows to process and detect events in the low-energy range down to Beryllium.

Decreasing the fast-filter threshold negatively impacts on noise sensitivity, which can in turn mask low-energy events and consequently reduce the OCR.

DANTE additional energy threshold is applied directly on the energy filter and works when no events are detected by the fast filter. This allows the user to set higher threshold for the fast-filter (reducing the noise sensitivity) and to set a lower threshold for the energy-filter, thus increasing spectra quality in the low-energy range.

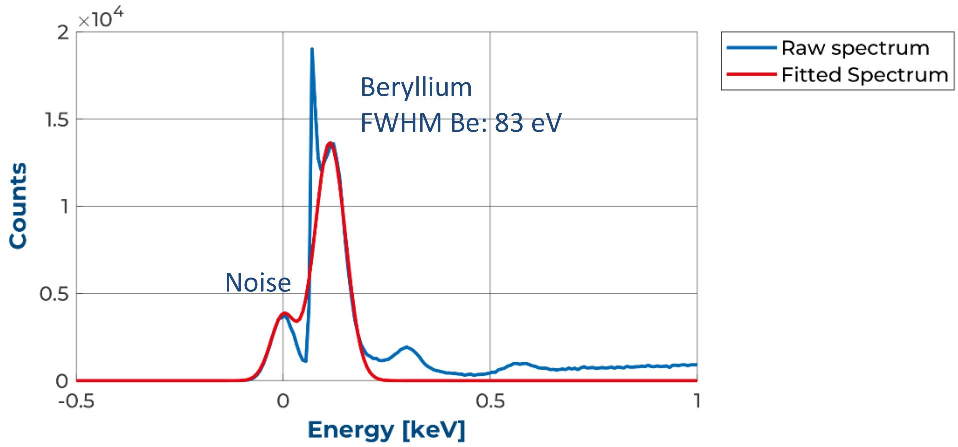


Figure 4.1: Achievable spectrum with Be sample and low-energy firmware.

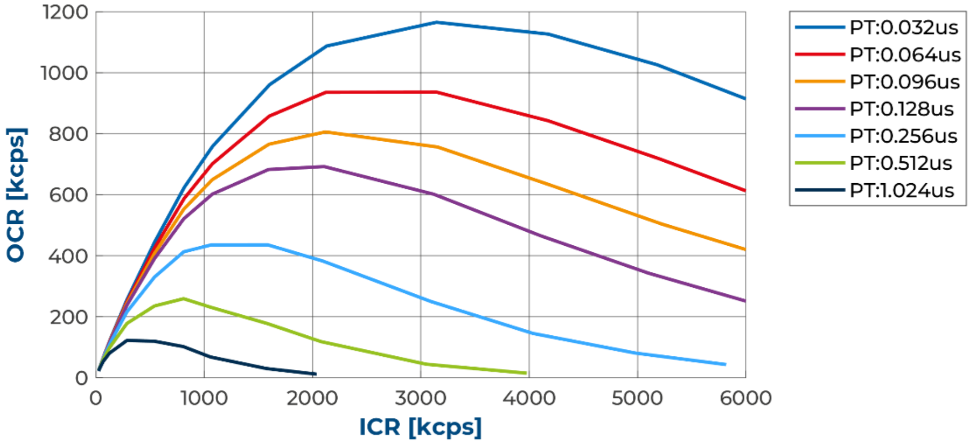


Figure 4.2: OCR vs ICR performances with 96ns flat-top

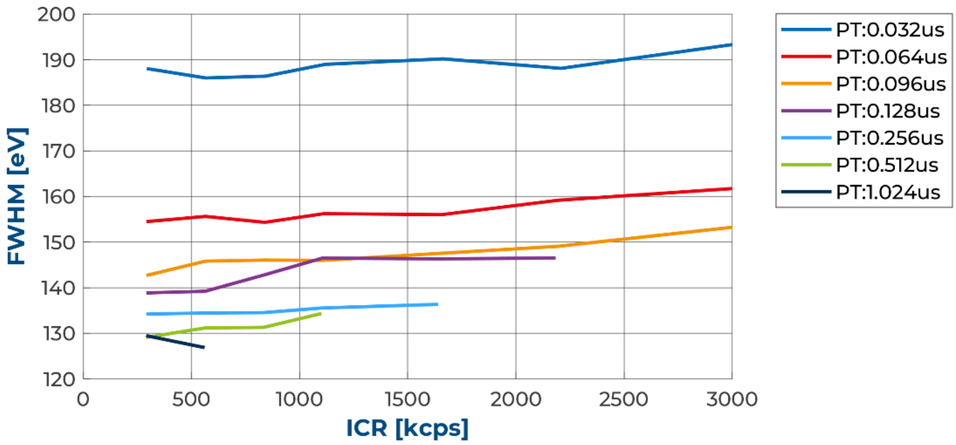


Figure 4.3: Stability of FWHM at different ICR for the low-energy firmware.

4.2. High-rate firmware

If high ICR with the best FWHM compromise is the target of the experiment, DANTE algorithm provides a variable energy filter peaking time. The algorithm dinamically select the best peaking-time optimizing both deadtime and energy resolution. The user should provide a range of peaking time in this operation mode:

- **Minimum peaking-time**: defines the system deadtime and rapresents the minimum peaking-time usable by the algorithm
- **Maximum peaking-time**: defines the best energy resolution achievable by the system.

Figure 3.4 shows different OCR-ICR curves for both standard filtering and high-rate filtering strategies. The orange high-rate curve (64-512 ns) shows the optimization in terms of deadtime and achieves the same performance obtained with the 64ns peaking time of the standard filtering algorithm. At the same time, the output count rate increases with respect to the fixed peaking time, in average by a factor of more than 3.5.

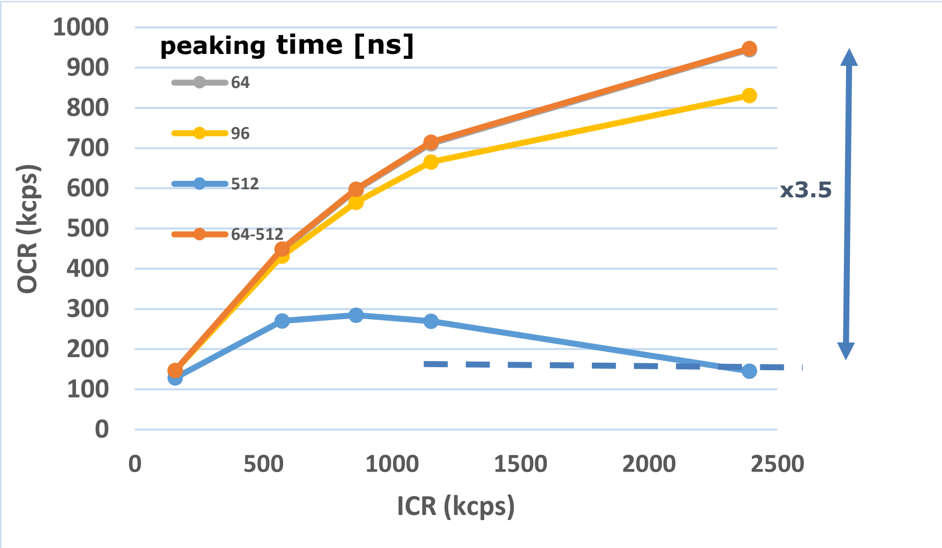


Figure 4.4: OCR vs ICR curve. High-rate mode allows to maximize OCR performance. Please note that grey curve (std-64ns) and orange curve (64ns - 512ns) are superimposed.

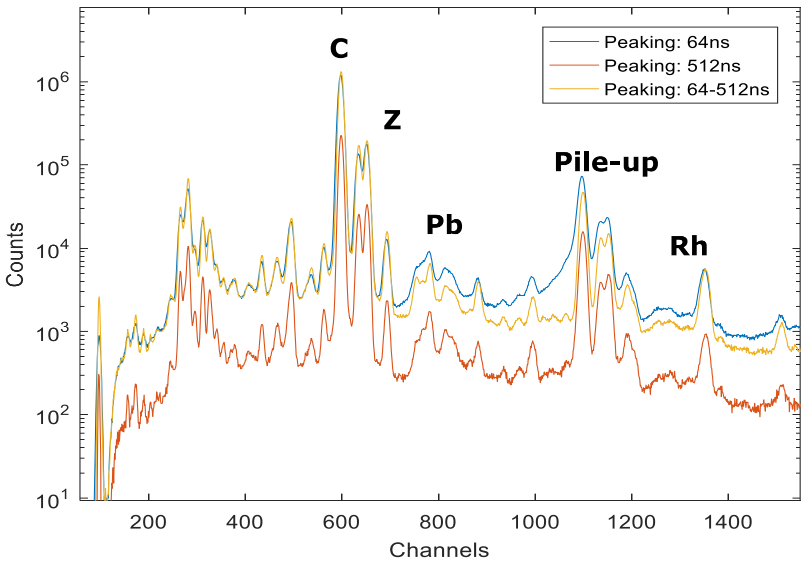


Figure 4.5: Comparison of spectra quality in standard-mode or high-rate mode.

Since the high-rate firmware is based on variable peaking-time, the resolution is not anymore stable with the ICR variation. High ICR means that, most of the time, shorter and shorter peaking-time will be selected by the firmware with a degradation of the energy resolution with respect to the low ICR performances. On the other hand, by comparing the resolution achievable at a fixed ICR-OCR ratio, the high-rate firmware allows to get the best energy resolution results.

Drawback of this approach is that events with the same energy, will be filtered by different peaking-time (automatically selected by the fw) which can results in non perfect gaussian peaks in the spectrum.

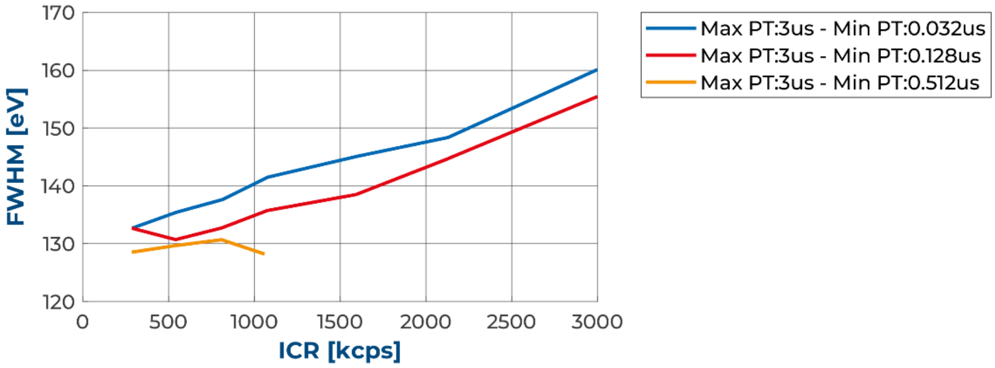


Figure 4.6: FWHM trend vs ICR in HR firmware.

5. DANTE Acquisition Software

5.1. Requirements

In order to quickly evaluate the DANTE DPP performances, a standalone graphical user interface is provided. The minimum system requirements are:

- Operative system: Windows Vista or later x86 or x64 (it could not work properly in Virtual Machines environments).
- An USB 2.0 port.
- Ethernet link supporting TCP-IP 100BaseTX or higher.

If an Internet connection is available, the USB drivers will be automatically found and installed by Windows Update the first time the board is plugged to the PC. Otherwise, you can also find the driver in the provided package (CDM21214_Setup.exe) and install it manually before connecting the board. In some OS you may need to install this driver twice. If the board is correctly detected by the system you should see under the Device Manager two devices named USB Serial Converter A and B:

5.2. Settings

Setting menu (see Fig. 5.1) provides global information of the application like the library and software version, serial number of connected devices, TCP/IP configuration and software upgrade capability.

Update Firmware section allows:
- Loading of a new firmware by using the default Load Firmware functionality.
- Recovery of the firmware in case of device-brick (USB Only).

Device Configuration section gives the possibility to change the IP and subnet of the USB connected device (active chains).
Communication Settings section allows to add IP addresses to check for a connection with DANTE devices. Although USB devices are automatically recognized by the GUI when connected, for ethernet connected devices the GUI need to know their IP first. Once added, the GUI will automatically search for a compatible device with the provided IPs.
Through **Saving Options** it is possible to change the default path for acquisition measurement files.

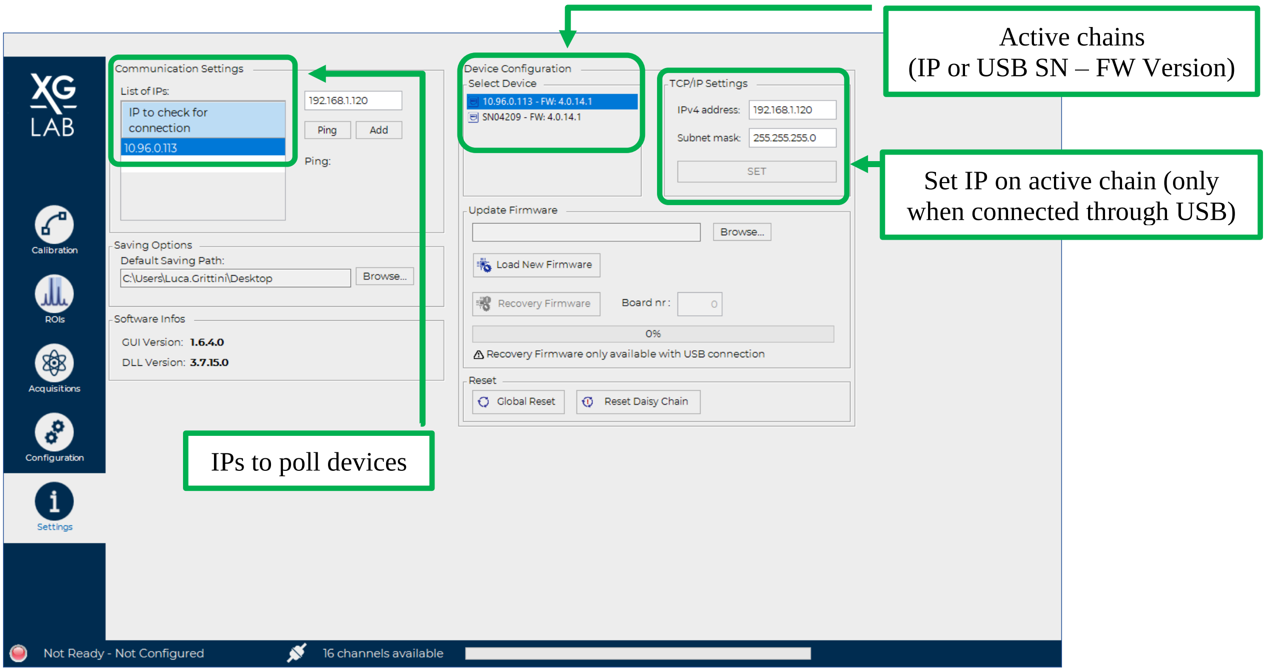


Figure 5.1: GUI settings panel

> **Warning**
> The IP will be not be set immediately but the change will take effect after a board power cycle.

> **Warning**
> In case of a device-brick, so when communication through library and device is compromised, the device will appear as "SNXXXX – FW-ERROR" in ""Select Device" list.
> In this way it is only possible to recover the firmware using the "Recovery Firmware" and inserting the number of boards of the box (e.g. 1, 8, 24, …).

5.3. Configuration

Each DANTE channel can be properly configured using the configuration tab section. A different configuration can be applied to each channel optimizing acquisition for different detector or performances. By default, same configuration is applied to all the connected channels through the *"Same Configuration to All"* switch button.

In case the user wants to store a particular configuration, it can be done by the "save configuration" button. In the same way, the user can load any previously saved configuration. In addition to the manual load and save feature, the GUI automatically save the current configuration for the boards in order to load it at the start-up. After the connection of a new board, the GUI will automatically search for a configuration related to the serial number of the new connected device. Once a configuration is loaded, configure the devices by pressing the *"Configure Selected"* button.

An additional consideration is required for the offset parameter which is used for shifting the input waveform inside the DANTE dynamic-range. Effect of this parameter can be seen using the waveform acquisition mode (Acquisition tab). For this reason, offset is the only parameter that can be changed both from the configuration tab and the acquisition tab.

If the *"Configure Before Start"* switch is enabled, All the channels will be configured before each acquisition is started. If a fixed configuration is used, it is recommended to keep this switch disabled. If this button is not enabled, please remember to configure the boards before starting an acquisition, otherwise the *"START"* button will be disabled.

If desired, channels can be individually disabled simply selecting the interested boards and switching *"Enable Channel"* to OFF.

Note
Please refers to Chapter 6 for a detailed description of the DPP parameters.

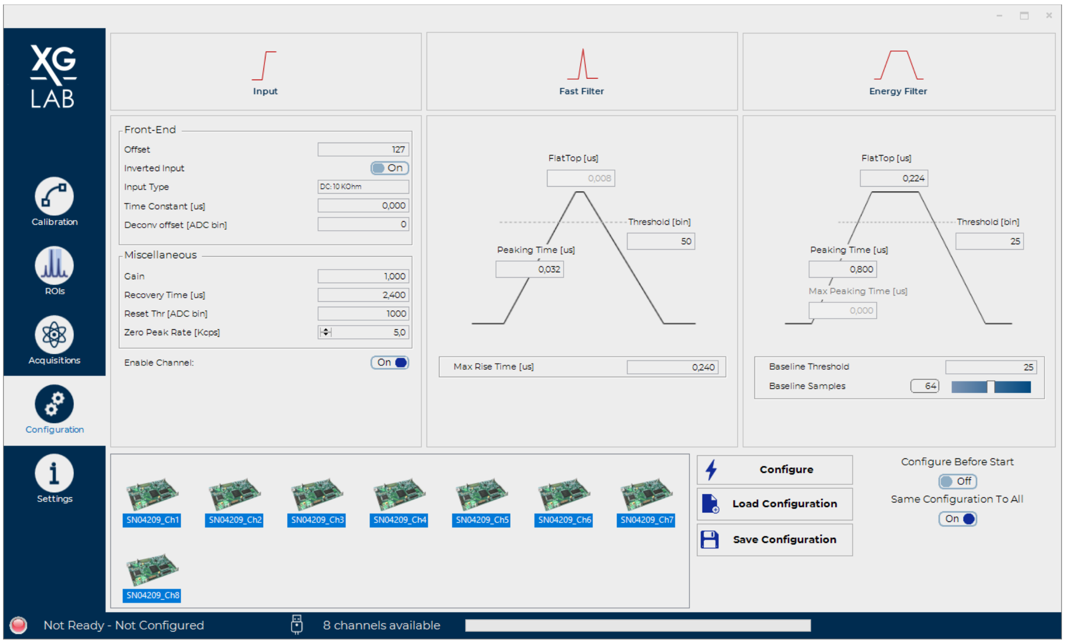


Figure 5.3: GUI configuration panel

Note
"Max PeakingTime" parameter is enabled only with the high-rate firmware version.

Note
Fast filter *"FlatTop"* is fixed and not selectable.

Note
When selecting *"Input Type"* to AC mode (22us or 2.2us) the default values of *Time Constant* and *Deconvolution Offset* are set as follows:

- AC 22us: *Time Constant* = 22, *Deconv. Offset* = 34400
- AC 2.2us: *Time Constant* = 2.2, *Deconv. Offset* = 32600

5.4. Calibration

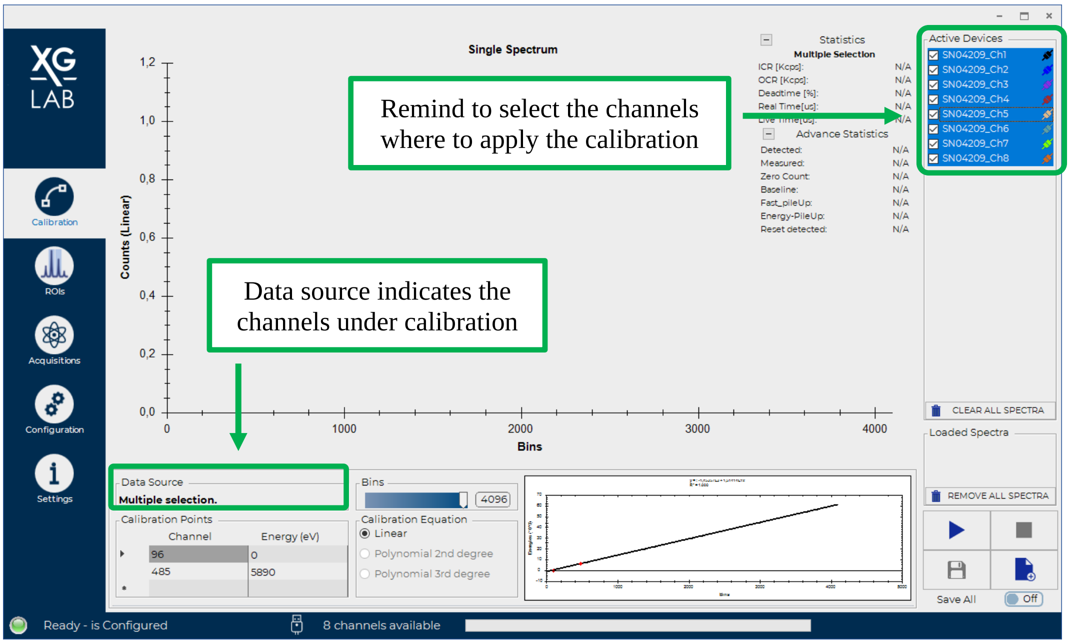


Figure 5.4: GUI calibration panel

Acquired and loaded spectra can be calibrated using the calibration tab. Currently only a linear fitting is supported which requires at least two points for a proper calibration.

Warning
Please note that the calibration is applied to the selected device only which is also identified in the *"Data Source"* tab.

Warning
Calibration Bins must be consistent with acquisition Bins.

5.5. Plot Management

Spectra plot region allows some flexibility in configuring the zoom and axis scale. By right-click the user can:

- Undo all zoom restoring full spectrum view.
- Change Y axis scale between linear and logarithm.
- Change X axis scale between bins (uncalibrated) and energies.

By default, the *"Show Point Values"* option is enabled which allows the user to see number of counts and bins/energies using the mouse pointer.

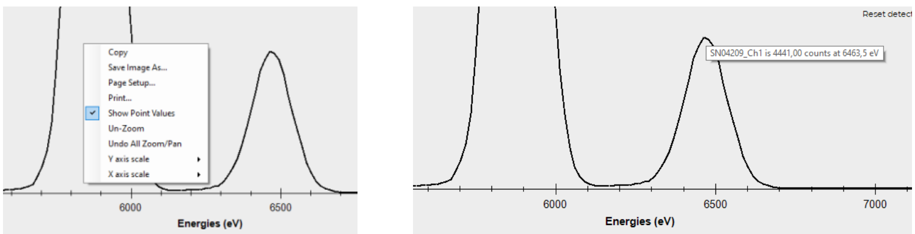


Figure 5.5: Plot settings

5.6. ROIs

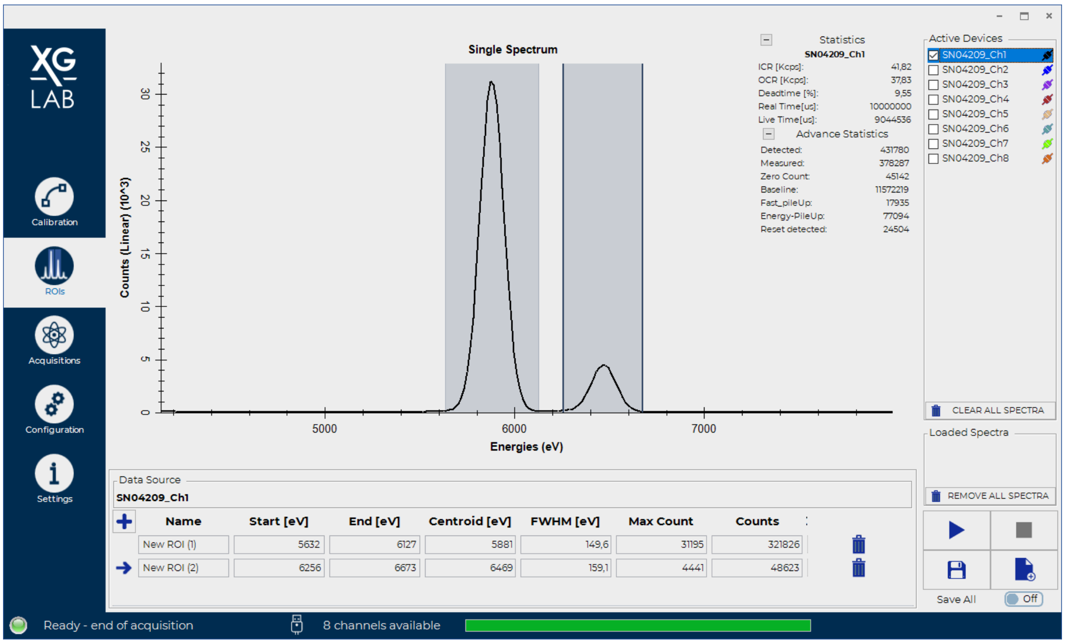


Figure 5.5: GUI ROIs panel

Acquired and loaded spectra can be processed using the ROIs tab. Multiple ROIs can be applied to the selected channel.

Once a new ROI is added (by pressing *"+"* button) the user can also resize it directly from the plot by moving its edges. For each ROI, following information are provided:

- Start, End: starting and end point of the ROI.
- Centroid.
- FWHM.
- Max Count: number of counts in the peak inside the ROI
- Counts: area of the spectrum inside the ROI

If a ROI is not used anymore, it can be deleted by pressing the trash icon. ROI can be applied both on online and loaded devices.

5.7. Debugging Functionalities

In special cases, it is also possible to make the DLL produce logging files that will help solving eventual problems. To enable this feature just place a file named *"enable_log.xgl"* (*.xgl* is the extension) with a number from 0 to 5 inside. 0 will produce a very detailed report while 5 will record only errors (2 is usually enough). We don't recommend using logging levels 0 and 1 for long sessions or when the DPP throughput is pushed to the limit, as this will slow down a bit the software. Please share us this log files when needed.

5.8. Acquisitions

Currently available acquisition modes are: Single spectrum, Mapping Mode, Waveform, List Mode, Sweep.
Noise peak sweep, List Wave mode will be available in next releases.

That's the appearance of the acquisition panel for most of the acquisition modes:

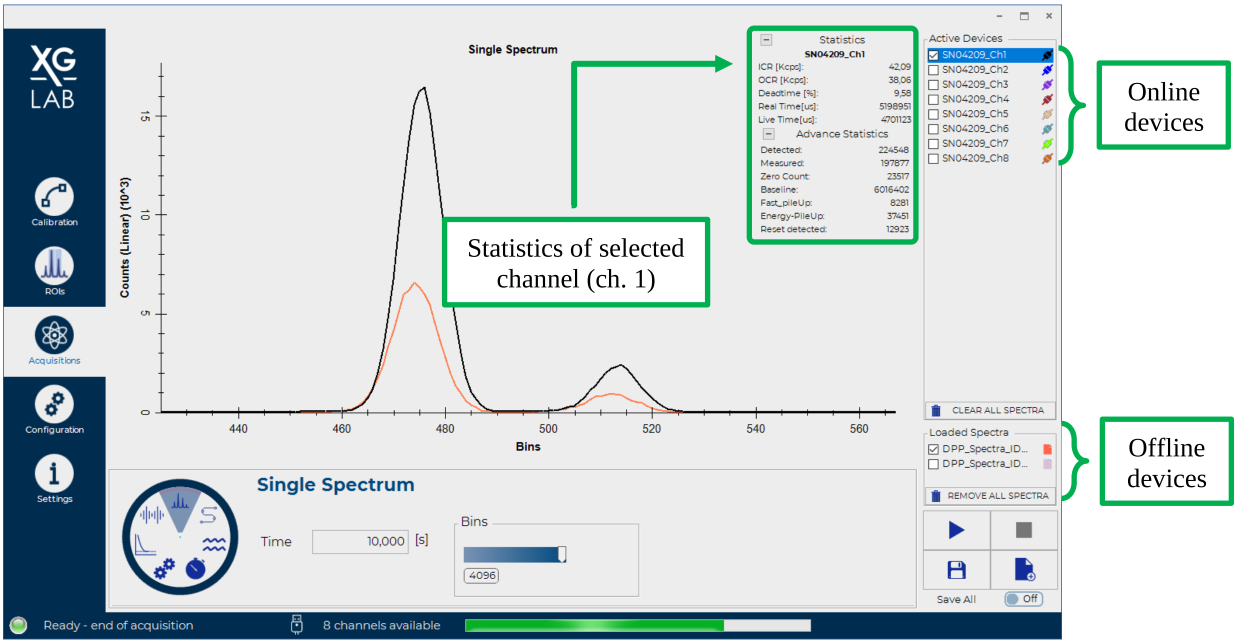


Figure 5.2: General acquisition panel

Once a device is detected, it will be added in the right panel of the main acquisition tab. All the listed channels are can be either selectable and/or checkable. Typically, the selection of a channel is used to show channel-related information like the statistics, FWHM, ROI counts etc. Checking of a channel is used mainly for adding/removing the acquired spectrum/waveform from the plot.

Together with the online channels, the software offers the possibility to load previously saved measurements. Channels contained in the saved files will be shown in the "loaded spectra" list as offline devices. Spectra of loaded channels can be shown and analysed together with the online (connected) devices.

5.8.1. Single spectrum mode

Single spectrum mode can be customized by the following parameters:

- **Real-time**: user-defined down to 1ms or free-running.
- **Bins**: 1024, 2048, 4096 supported.

Together with spectra, DANTE sends statistics information (i.e OCR, deadTime etc.) which are updated every 100ms.

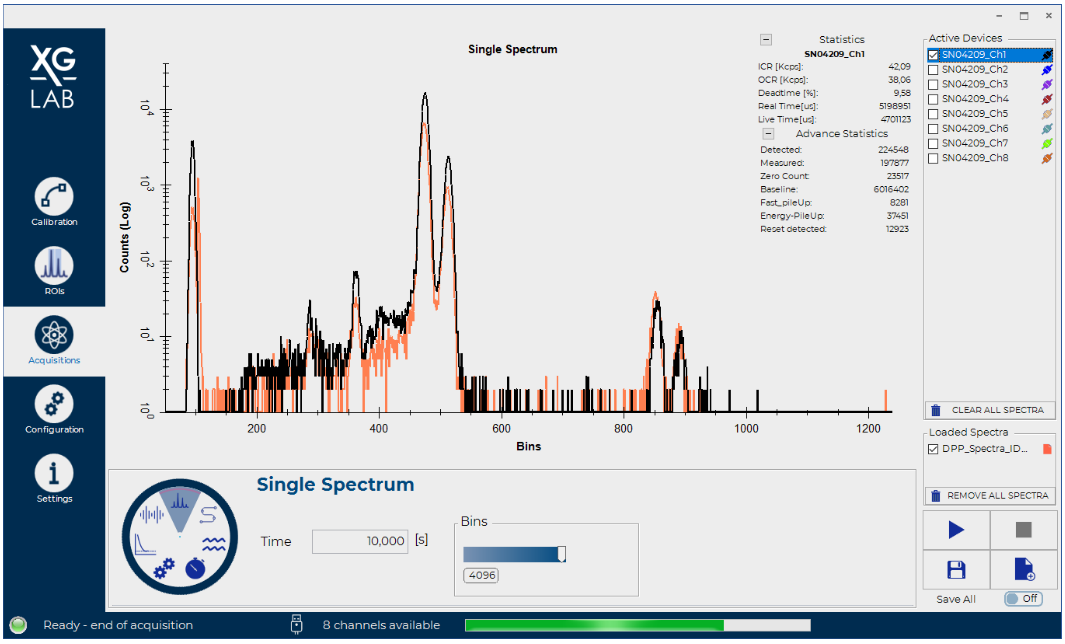


Figure 5.6: GUI single spectrum acquisition mode

For a free-running measurement the user must set a time value of '0'.
"STOP" button immediately terminates the acquisition, also if spectra time was set.

During the measure, statistics information will be update in real-time and are shown in the top-right panel of the graphic window. By changing the selected device, statistics are updated accordingly. By default, all the devices are checked which means that all the spectra are shown in the plot. To hide some channel's spectrum, it must be unchecked.

Acquired spectra can be:

- Automatically saved in *.hdf* file format if the *"Save All"* is enabled
- Saved either in *.hdf* or *.mca* file by pressing the save button

By pressing the loading button, offline spectra can be loaded, and the *"Loaded Spectra"* list box will be populated accordingly. Analysis of both online and offline spectra can be done in the ROI tab after proper calibration.

Note
Only *.hdf* file can be loaded and processed by the software.

5.8.2. Waveform mode

Waveform mode allows to acquire the input signal waveform with a frequency up to 62.5Msps and a resolution of 16bits.

Like an oscilloscope, the acquisition can be customized based on the following parameters:

- **Acq. Length:** specifies the desired length of the waveform and is expressed in 16384 samples unit. For example, if length is set to 1, 16384 samples are acquired; if set to 2, 32768 sample are acquired; etc. ATT: slider is not linear.
- **Decimation:** indicates the decimation of the acquired samples, from 1 to 32. If set to 1 the waveform is sampled at 62.5MHz. If set to N, one sample every N samples is acquired.
- **Offset:** Selected waveforms can be shifted inside the DANTE dynamic-range by changing the offset slider. The new offset value will be updated also in the configuration tab. ATT: slider cannot be changed during acquisition.
- **Triggers and threshold**: The user can specify a trigger for the waveform acquisition that can be an either the rising or the falling edge with a threshold level specified in ADC bin units (from 0 to 65535). A combination of the various triggers can be also selected, and the acquisition will be triggered by the first event that happens.
- **AUTO or SINGLE**: if *"AUTO"* switch button is selected, the start of acquisition is fired iteratively. If *"SINGLE"* is selected, the start is given once.

Figure 5.6: GUI waveform acquisition mode. Example of waveform acquired configuring the trigger to detect reset event.

When *"Save All"* switch is enabled, all the collected waveform will be automatically saved in *.hdf* file format.

5.8.3. Mapping mode

DANTE offers the possibility to acquire multiple spectra down to 1ms and without dead-time between consecutive spectra.

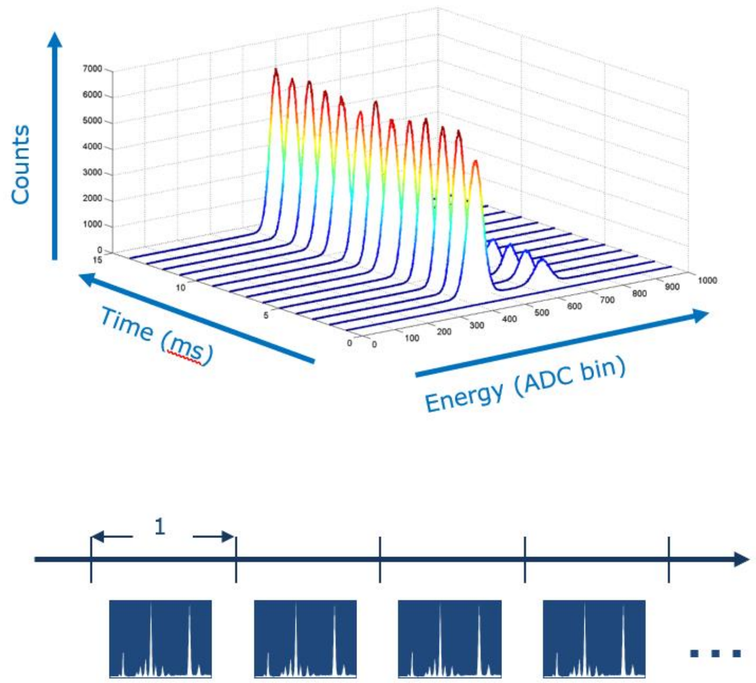


Figure 5.7: continuous acquisition of spectra down to 1ms with zero dead time between spectra

DANTE DPP can be configured to acquire accordingly to an external logic input (*"AUX"* or *"DIG"* signal, see Chapter 3) as advancing pixel method. Gating acquisition only affects multiple spectra acquisitions.

Three possible gating/trigger modes can be selected for the mapping acquisitions:

- **Free running:** gating/trigger input is ignored by the DPP, and a new spectrum is acquired every time the user-defined timeout *"Time"* elapses, until all points, defined by *"Points"* have been collected.
- **Gated:** a new spectrum is acquired every time the gating input is either low or high (depending on "*Active LOW/Active HIGH*" setting), and the DPP is kept inoperative while the input is inactive.
- **Triggered**: With the "triggered" mode the DPP is always active, and a new spectrum is initialized every time an edge on the input trigger signal occurs; depending on the corresponding setting, the new spectrum can either be initialized on rising edges, on falling edges, or on both rising and falling edges.

The number of acquired spectra is available in the advanced statistical panel.

For unlimited measurement the user must set *"Points"* equal to *'0'*, in order to acquire an undefined number of points (equal for all boards of a chain), until a *"STOP"* is pressed. *"STOP"* button immediately terminates the acquisition, also if higher number of points was set.

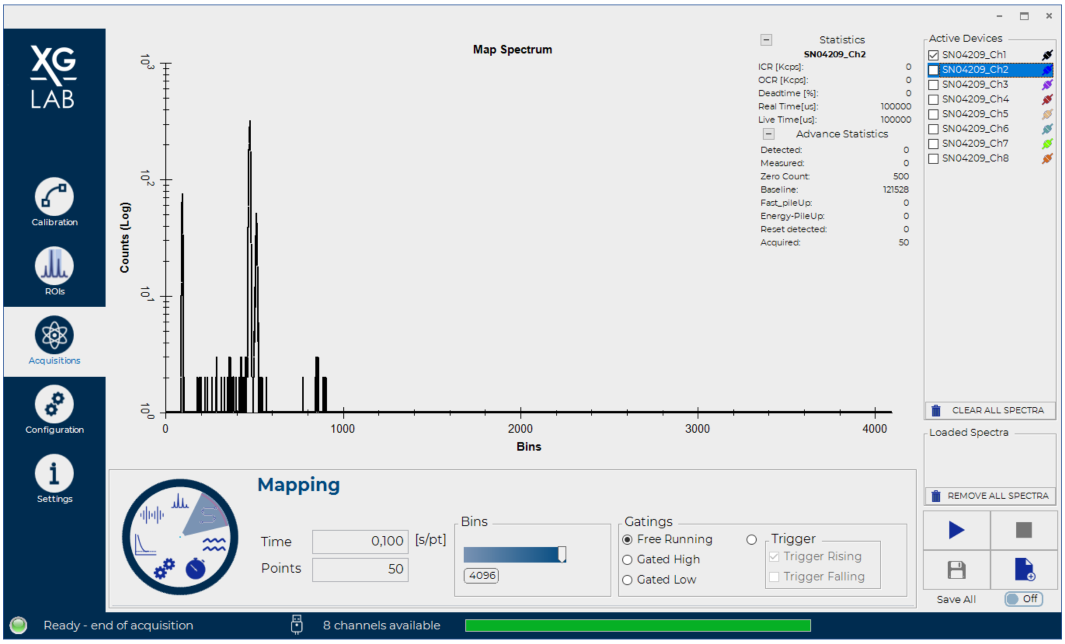


Figure 5.8: GUI mapping acquisition mode

Note
Maps are <u>only</u> available at 4096 bins.

Note
Saving acquired points, to prevent file of big dimension, a new *.hdf* file is created every time the acquisition reaches a total of 5000 spectra.

Each gated/triggered operating mode is schematized in the following figure, where the active period for each spectrum is highlighted with blue arrows.

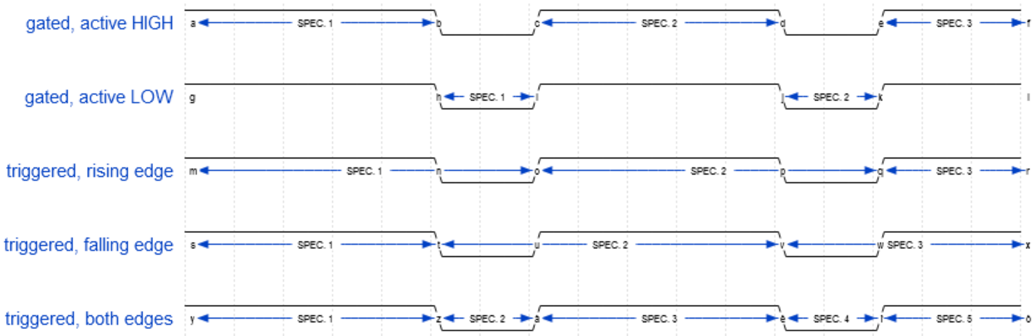


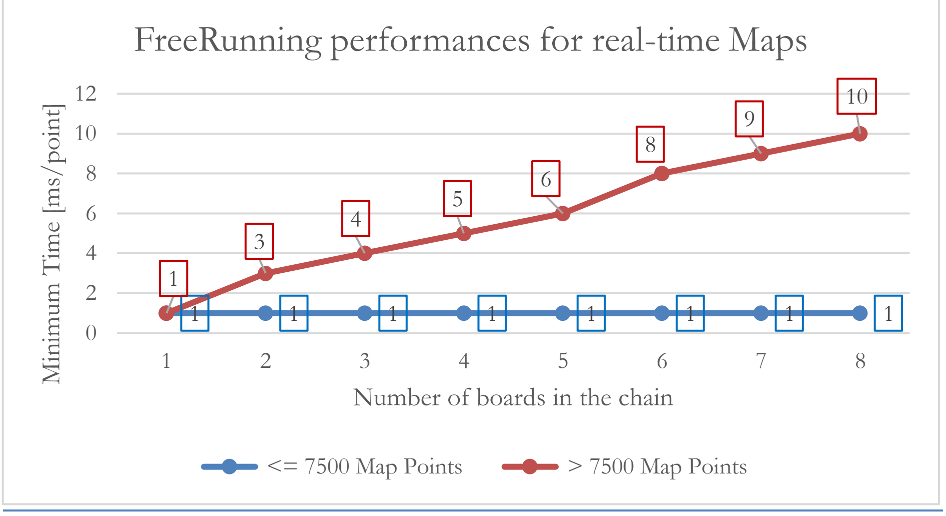
Figure 5.8: Gating – trigger modes supported by DANTE mapping mode.

The minimum spectrum time achievable by the mapping mode is affected by the number of channels connected to a single USB-TCP/IP connection and the number of *"Points"*.

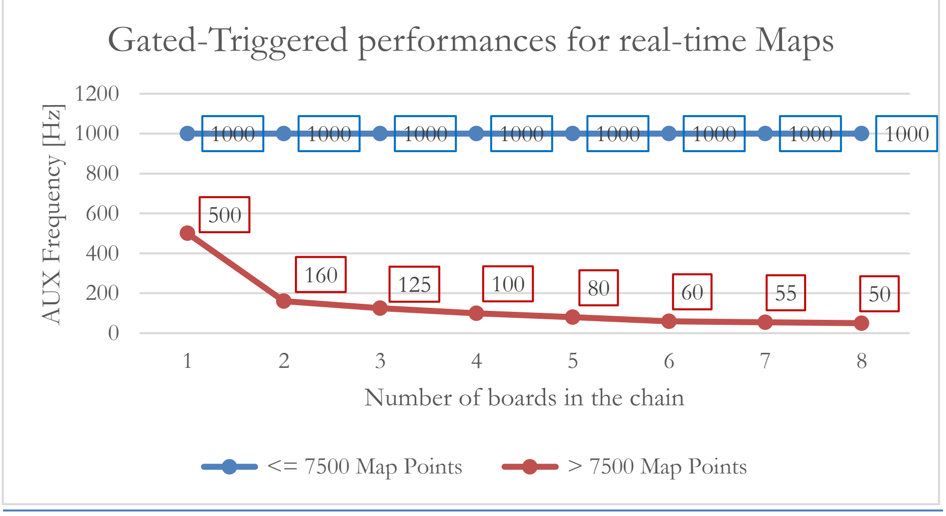
Since each DPP mounts a RAM module that can contain up to 7500 spectra, if *"Points"* is lower than 7500, spectrums of 1ms can be collected independently by the number of connected boards.
For maps with a number of *"Points"* greater than 7500, the minimum acquisition time only depends on the number of channels connected to a single USB-TCP/IP connection.

The user should refer to the following table to understand the limits to operate in real-time acquisition, both for FreeRunning and Gated/Triggered maps:

FreeRunning:



Gated or Triggered:



With some slower PCs or network adapter it could happen that the maximum Ethernet bandwidth is 60 Mbps, so when doing very short spectra the throughput can be limited by the connection. In order to reach this throughput is highly recommended to disable the WiFi adapter, if present, in order not to overload the network adapter.

Anyway, DPP will not block if the desired transmission speed exceeds the maximum achievable throughput: it will just start to drop some spectrum if not capable of retrieving them all in time. If this occurs, it will be signaled by the GUI displaying the MISSED_SPECTRA error code (which can be seen in the DLL header or in the DLL manual).

Warning
In *"gatedHigh"* and *"gatedLow"* modes it is required that the AUX signal has, respectively, a minimum gate-low (T-OFF) and gate-high (T-ON) duration at least greater than 1ms.

5.8.4. List mode (Energy-Timestamp)

In the energy-timestamp acquisition mode, DANTE provides all the recorded energies together with the timestamp of their arrival with a resolution of 8ns. Periodically, also statistics information of the acquisition are sent together with data.

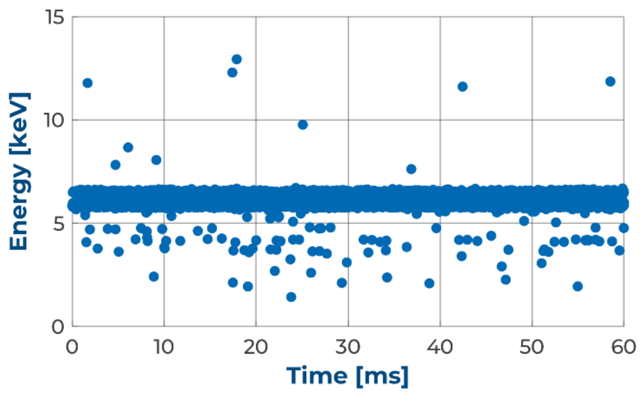


Figure 5.9: real-time throughput of energy and timestamp for each photon event with 8ns precision

Multichannel version provide synchronization of timestamp among all the connected channels. Be aware that clock propagation is affected by the length of the chain (number of connected channels): An average fixed offset of about 32 ns/channel should be taken into account. Since a decimal number for the delay can be quite difficult to manage, DANTE library offers the possibility to properly compensate the propagation offset in order to make it integer multiple of 8ns.

The USB or TCP/IP connection can handle OCR up to about 2.5 Mcps. If this rate is exceeded, events will likely be lost, and this will be indicated in the acquisition statistics. Please consult the library manual for further details about the statistics and error.

Warning
Please be aware that currently, event detected only by the energy filter do not provide a meaningful timestamp. Timestamp is latched only if fast-filter threshold is overcome. To prevent possible issues (i.e. coincidence analysis) please disable Energy Filter by setting *"Energy Filter Threshold"* to '0'. For the same reason, for energy-timestamp analysis only, the *"Zero Peak Rate"* should be set to '0'.

Note
High-rate firmware supports 32ns timestamp resolution only.

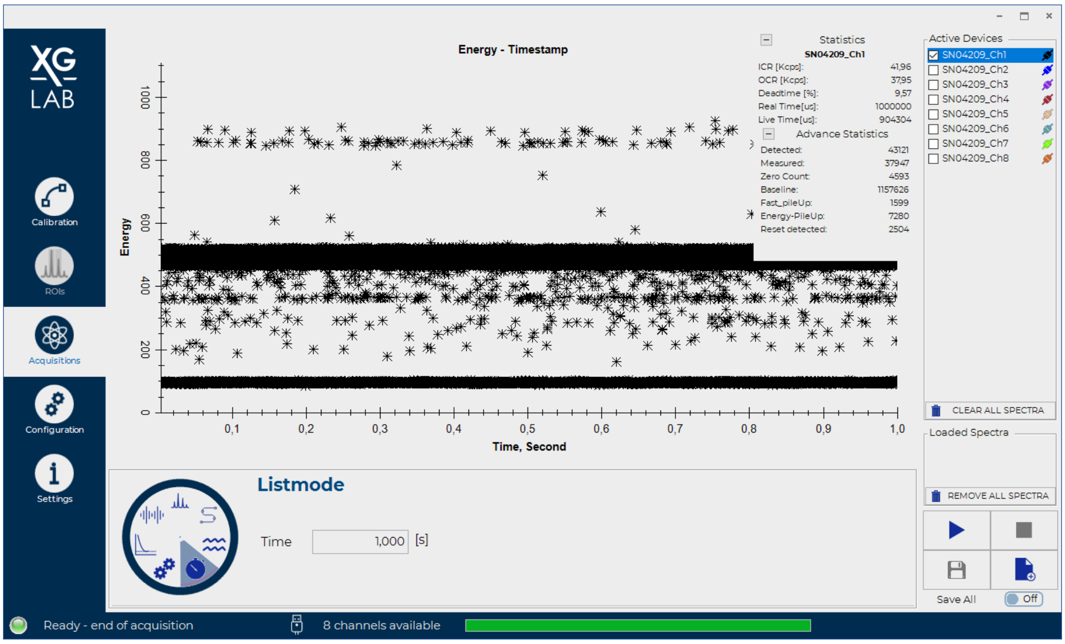


Figure 5.10: GUI list mode acquisition mode

Each event is displayed with a "cross" point in the graph table.
If *"Save All"* is ON, an individual *.hdf* file per channel is generated.

5.8.5. Combined List-waveform mode

The energy-wave mode is an extension of the energy-timestamp mode which, together with energies and timestamps, provides an user defined time-window waveform for each detected events.

Energy-Wave mode can be customized with the parameters shown in the following table.

Parameter	Unit	Range	Range [us]
Waveform length	16 ns sample	8 to 1256	0.128 to 20us
Pre-trigger	16 ns sample	0 to 600	0 to 9.6

The *pre-trigger* slider can be used for shifting the time-window around the edge of the triggering signal. *pre-trigger* is a relative value and depends on the *Energy-Filter Peaking-Time*. A default value of *'4.8us'* should allow to see the edge of the recorded events (set also *Zero Peak Rate* to *'0'* and *Energy-Filter Peaking-Time* to *'25'*).

It can happen that inside the time-window of the processed event, another event is detected as shown in the following picture. In this case the second event is discarded and won't be processed by the DPP.

Warning
Energy-wave mode is only available in the Matlab-based debug GUI (available on request). Every time an acquisition is finished all the data are automatically saved in a *.mat* file in folder *"measurement"*.

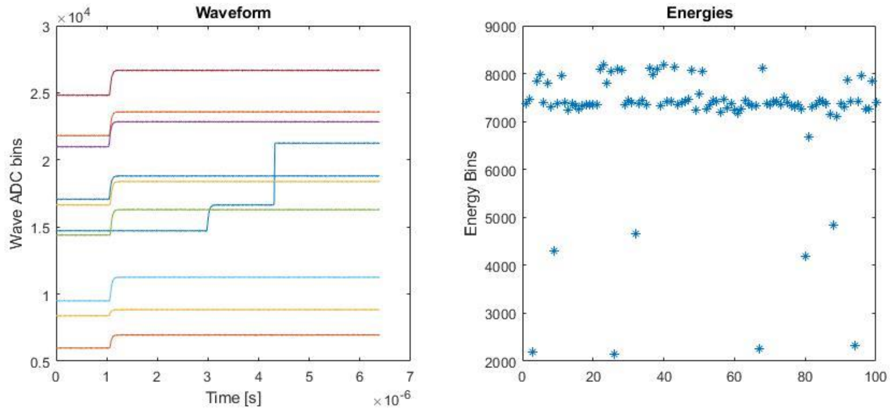


Figure 5.11: (left) waveform for each recorded event. (right) energy of each event.

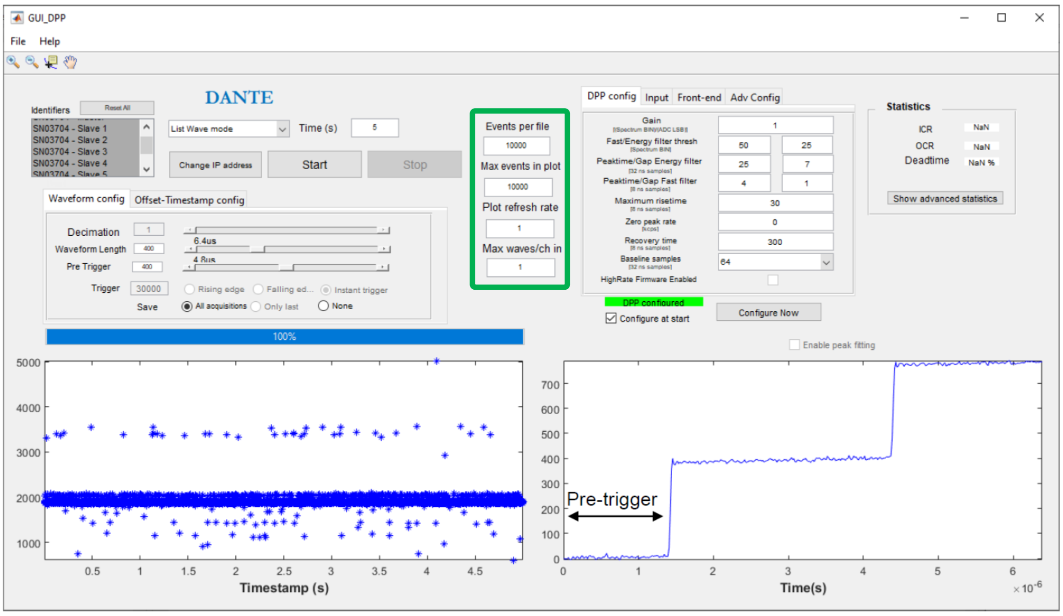


Figure 5.12: Matlab-based debug GUI combined list-waveform mode

Other parameters to set are:

- **Events per file:** number of events to be saved
- **Max event in plot:** number of energy-timestamp in the plot on the left
- **Max waves/ch in:** numbe rof waveforms in the plot on the right

List-wave mode is very demanding in terms of bandwidth and can sustain relative low count rate. Given a maximum throughput of 80Mbit/s (TCP/IP connection), consider the following formula for a rough estimation of the maximum input count rate.

$$OCR_{max} \approx \frac{80Mbit/s}{N_{ch} \cdot 64bit \cdot wave\ length}$$

In case the limit is overcame, the hardware memory may become full during the acquisition.

Based on the throughput limitation, the possibility to internally limit the rate of processed events (independently to the ICR) has been implemented by correctly configuring the DPP core. Please see the library manual for furhter details.

5.8.6. Sweep mode

Sweep mode allows the user to do multiple acquisitions varying one parameters at a time. This can be useful in order to evaluate the optimal value of such parameter to optimize the resolution of the acquisition. Sweeps are available in panel Acquisitions → Sweep.

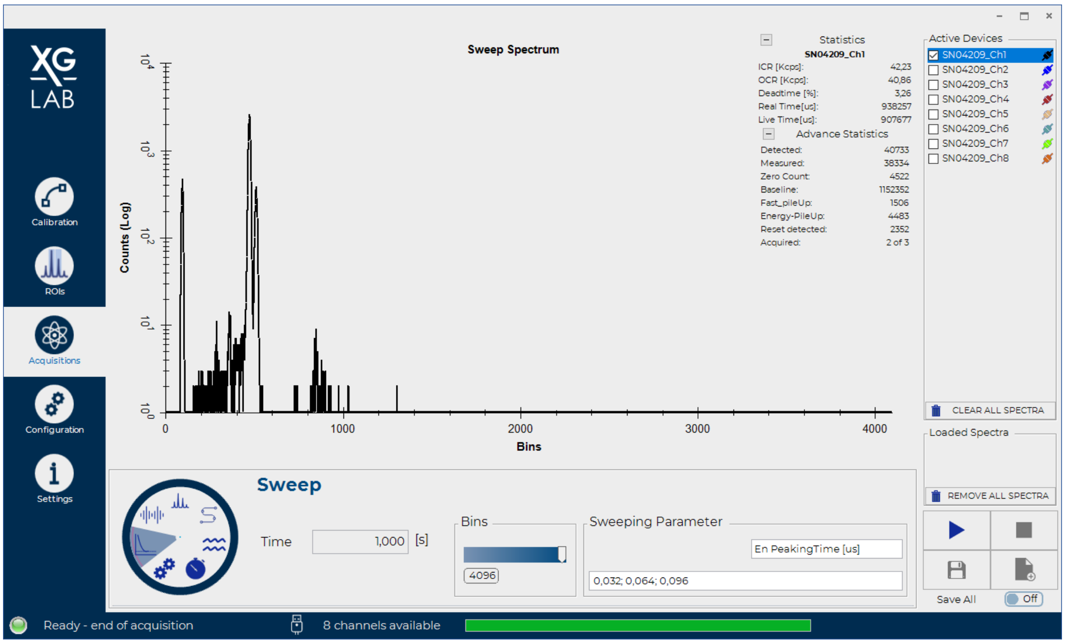


Figure 5.13: GUI sweep acquisition mode

The user has to set Time and Bins as a Single Spectrum acquisition.
The sweep parameter can be chosen in the tab "Sweeping Parameter". Once selected, a default array of values will appear for any choice, which can be changed depending on the user's needs.

Note
Values must be inserted interspersed by ";". If the string of values inserted is not consistent, an error message which advises the user will appear.

The available sweeping parameters are:
- Energy-Filter PeakingTime [us]
- Energy-Filter FlatTop [us]
- Energy-Filter Threshold [bins]
- Fast-Filter PeakingTime [us]
- Fast-Filter Threshold [bins]
- Max Risetime [us]
- Recovery Time [us]
- Baseline Threshold [bins]
- Time Constant [us]
- Deconvolution Offset [units]
- Reset Threshold [bins]
- Baseline Samples [units]
- Offset [units]

In "Advance Statistics" the parameter "Acquired" indicates the current sweep acquisition number among the inserted values.

The user can press "STOP" to force the end of the acquisition, even if there are still sweep values remaining.

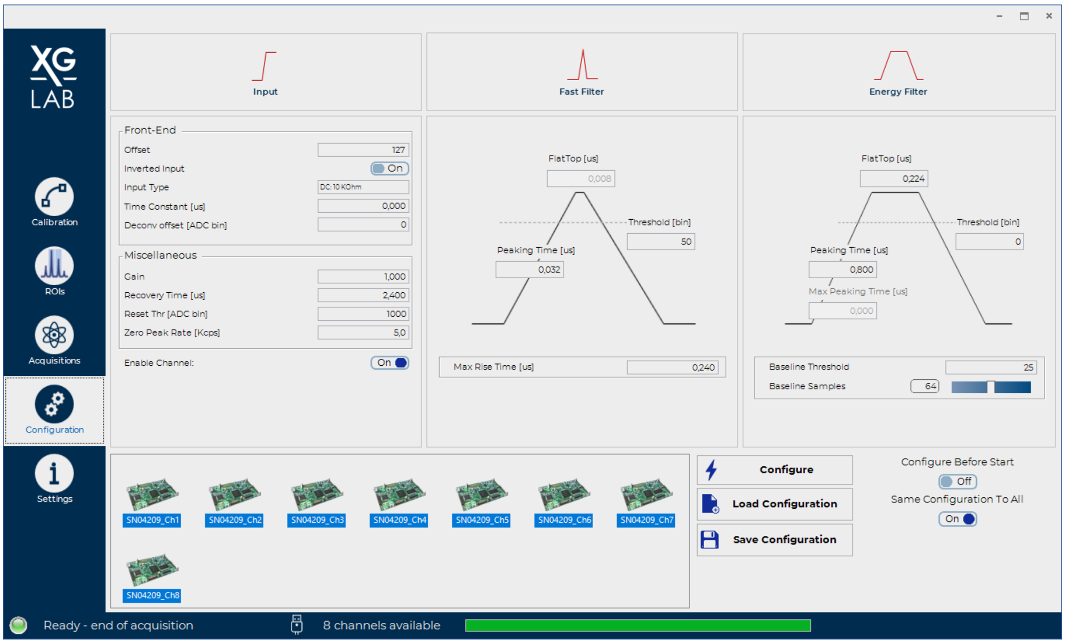
If *"Save All"* switch button is ON, a *.hdf* file will be saved for each sweep acquisition (the structure of the file is the same of the mapping mode, a part from the multiple settings). The *.hdf* file has the sweeping parameter in its name, in order to recognize it.

Warning
In order to prevent unexpected parameter changes, when a Sweep is started, the entire current parameter settings before Sweep is saved and then recovered after the end of the Sweep.
In this way, at the end of the Sweep, the sweeping parameter is reset to the value which had before the start.

6. DPP Parameters

DPP Parameters are settable in the Configuration Panel of the DANTE Acquisition Software. They are organized as follows:

- **Input Parameters:** contains Front-End and Miscellaneous settings which allow to properly set-up the input signal and set part of filter settings.
- **Fast-Filter Parameters:** allow to set-up the Fast-Filter (detection filter).
- **Energy-Filter Parameters:** allow to set-up Energy-Filter (measurement filter) and Baseline-Filter (correction slope factor filter).



In the following sections, all these parameters are explained in details and the procedures to the choice of the main parameters are illustrated.

Please note that default values are provided for all the parameters. They have been chosen as standard values for the following condition test:

- Detector SDD 30 mm^2, CUBE ASIC
- Preamplifier gain 7mV/keV
- Temp = -35 °C
- ICR = 20 kcps
- Irradiation source = ^{55}Fe

6.1. Input Parameters

6.1.1. Front-End

Offset

It's possible that even if the premaplifier output is whithin $3V_{PP}$, its dynamic is outside the ADC dynamic-range. If this situation occurs, waveform will be clipped resulting in a loss of events and a high dead-time.

DANTE provides a programmable analog offset to correctly allocate the input signal coming from the detector/preamplifiers into the DANTE dynamic. Waveform acquisition mode should be used to be sure that the dynamic range is fullfilled.

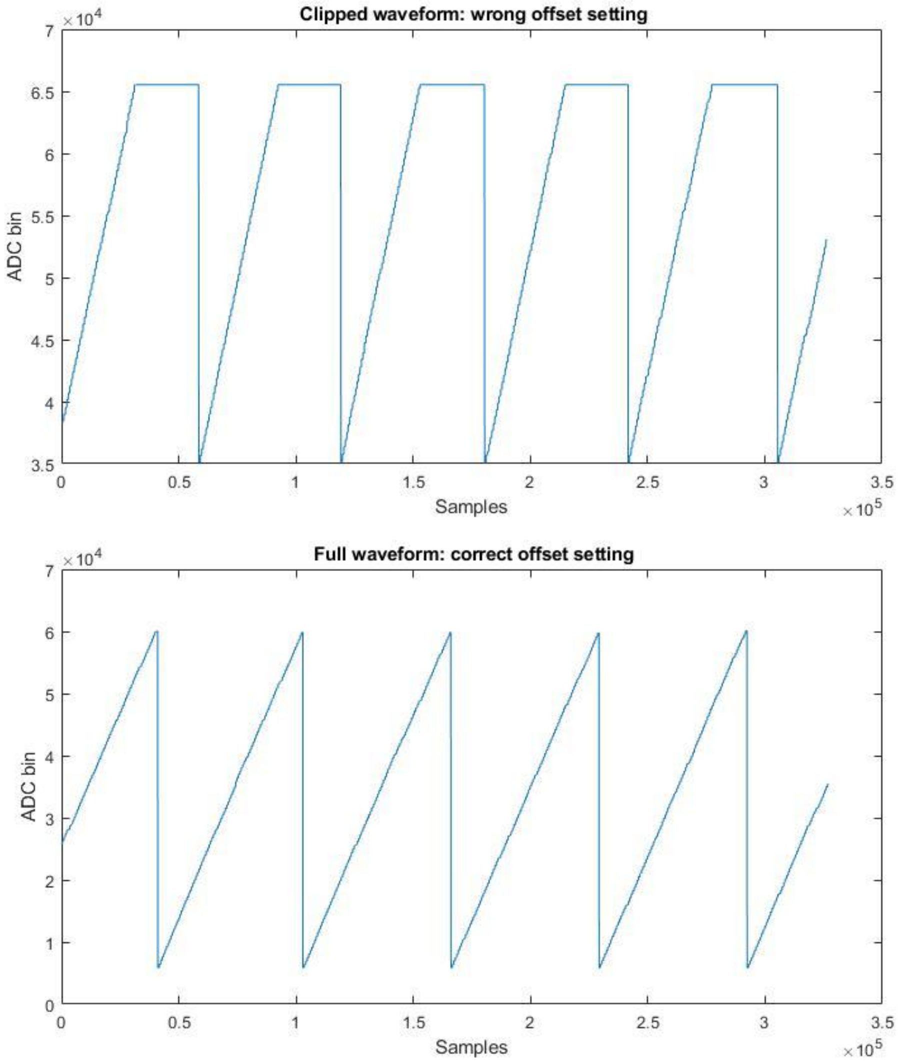


Figure 6.2: (top) Saturated waveform due to a wrong offset setting. (bottom) waveform correctly centered into the ADC dynamic-range after offset calibration.

Inverted input

For correctly applying the trapezoidal filtering, DANTE requires positive pulses from the preamplifier. In order to cope with negative pulses DANTE provides the possibility to digitally invert the acquired waveform.

Front-end selection

DANTE DPP is equipped with a reconfigurable input front-end. Possible configurations are:

- DC high Impedance: 10 KOhm
- DC low impedance: 1 KOhm
- AC High Impedance: 22 us
- AC low impedance: 2 us

In case of preamplifiers with an output dynamic range within $3V_{PP}$, it's highly recommended to use only the input DC coupling. The AC coupling can still be used for matching the compatibility with different preamplifiers with output dynamic range higher than $3V_{PP}$.

Deconvolution Offset and Time Constant

DANTE is compatibile both with step and exponential signals. However, in order to correctly apply the trapezoidal filter, exponential pulses needs to be deconvolved. *Deconvolution Offset* and *Time Costant* are needed to deconvolve the input signal correctly.

- **Deconvolution Offset**: steady-state value of the input waveform when the deconvolution is disabled and there are no events. This can be retrieved from the waveform acquisition.
- **Time Constant**: time constant of the input exponential pulses.

Once the deconvolution is applied, deconvolved waveform can be seen using the waveform acquisition mode. Please note that deconvolution will generate a leakage which is similar to a ramp and can be confused with a pulsed-reset ramp.

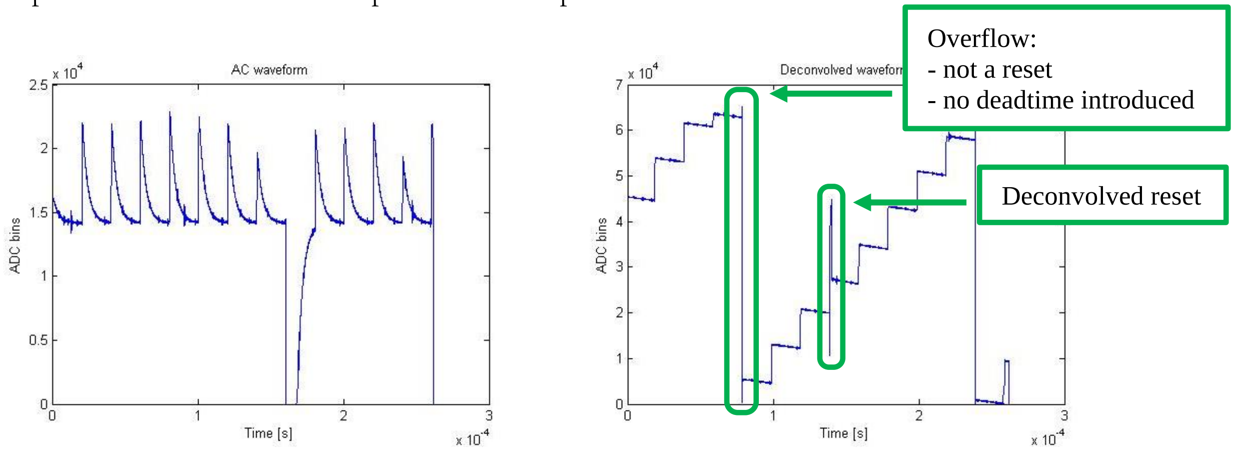
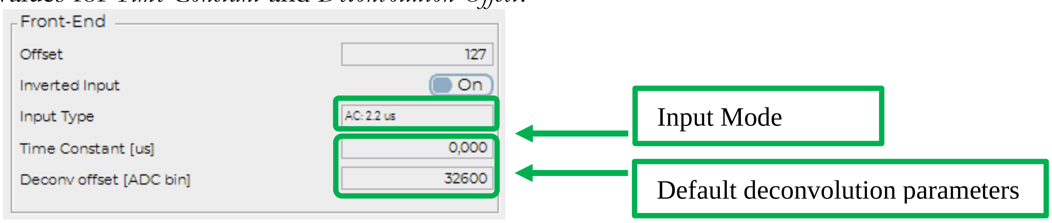


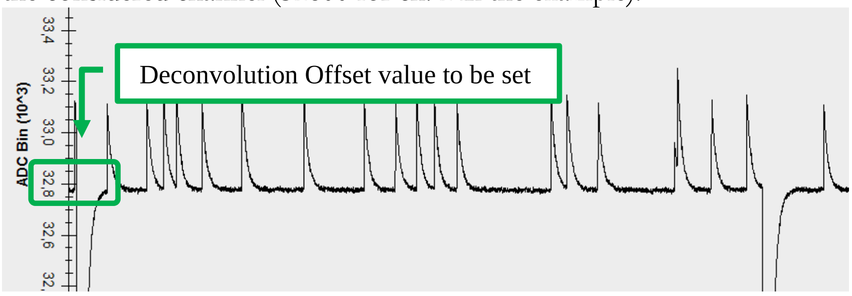
Figure 6.1: (left) waveform with exponential pulses. (right) deconvolved waveform

Here below it is described the procedure to correctly configure *Time Constant* and *Deconvolution Offset* depending on the AC Input Mode selected in Acquisition GUI:

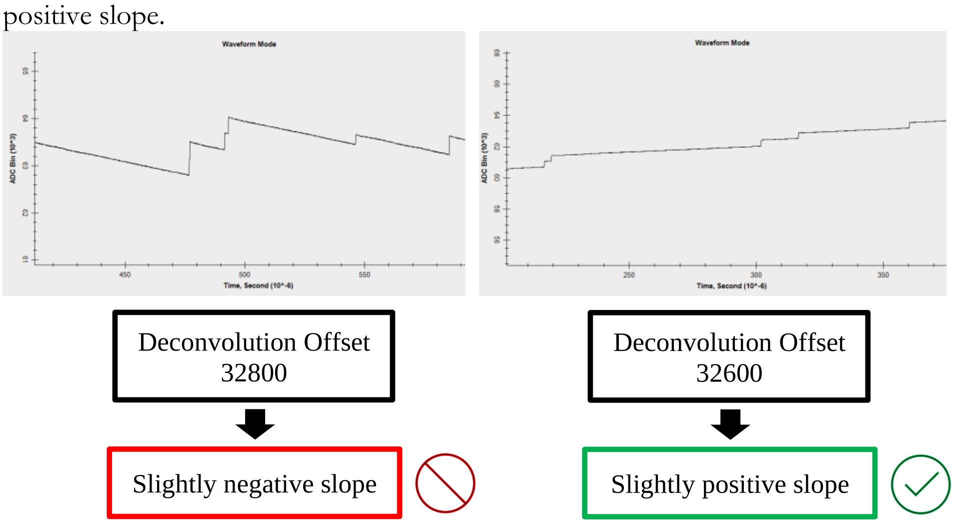
- In Configuration panel, select the AC 22us or AC 2.2us. Software will set default values for *Time Constant* and *Deconvolution Offset.*



- Set *"Offset"* as previously described.
- Set *Time Constant* to *'0'* and click *"Configure"*.
- Go to the Waveform acquisition panel and launch an acquisition <u>without any signal.</u> The average value of the waveform you read will be the *Deconvolution Offset* to set for the considered channel (32800 for ch. 2 in the example).



- Now the value of the *Time Constant* has to be defined. Tipically, for AC 2.2us a *'2.2us'* of *Time Constant* is the preferred value as *'22us'* for AC 22us Input Mode. However, it can be that some value around these would be the optimal one. To determine it, a Sweep (See Chapter) of *Time Constant* value can be done to see which settings mazimizes the resolution.
- Check if each step is almost flat, in order to ensure a good baseline correction (slightly positive slope is better with respect to slightly negative slope). If the slope is negative the user has to slightly reduce the *Deconvolution Offset* parameter, until it has slightly positive slope.



6.1.2. Miscellaneous

Gain

Digital gain applied to ADC samples. This parameter can be used to choose the dynamic range of interest in the spectrum. Being only a digital gain this does not have any impact on the achievable resolution.

Warning
Remind to adapt Fast-Filter and Energy-Filter thresholds when changing the gain.

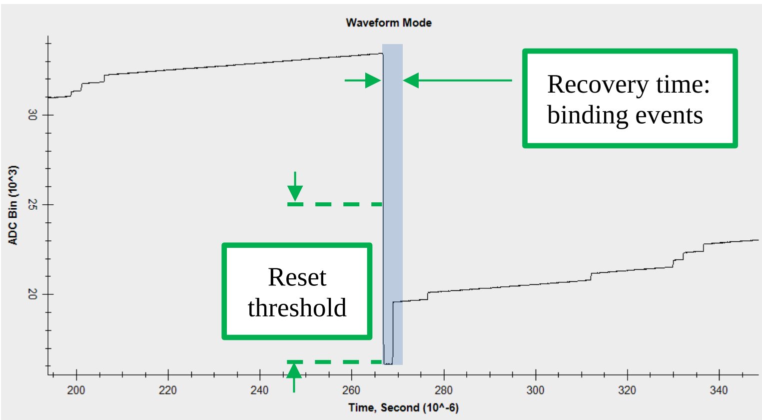
Recovery time

After the reset detection, following events are ignored for a time window set by the recovery time.

Reset threshold

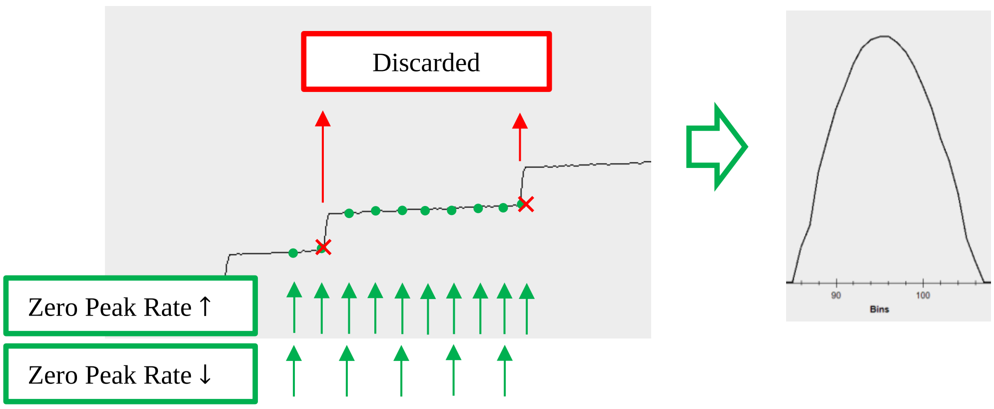
Threshold to detect the reset on the input analog waveform. The reset is detected when the following expression is satisfied:

ADC(n) - ADC(n-8) > THR



Zero-peak

Enabling the zero peak rate, DANTE will acquire the filter output periodically when there are no input events. This feature can be disabled setting the rate to 0. Result of zero-peak acquisition are a dummy events around bin 0. Since the whole spectrum is shifted by 96 bins, the zero-peak (sometimes called artifact) will be centered around 96.



6.2. Fast-Filter Parameters

Peaking-Time, Flat-Top and Threshold

Standard detection of events is done by a combination of the fast-filter peaking-time and the fast-filter threshold. Fast filter output is compared with the set threshold: if higher, the event will be then processed by the Energy filter, otherwise the event is discarded. Like the energy filter, peaking-time can be selected for the fast filter but are expressed in unit of 8ns. The Flat-Top is set to 8ns, since Fast-Filter must be very similar to a triangular filter.

Since the fast filter threshold is not simply a cut of the reconstructed spectrum, it can happen that noise peaks whose energy (expressed in bin) is less than the threshold, appear in the spectrum. This is true for noise or interference. Since they are not real steps in the ramp, a short fast filter can have an output which is higher than the detection threshold; then the longer energy filter, filters out the spikes reconstructing an energy which can be less than the threshold.

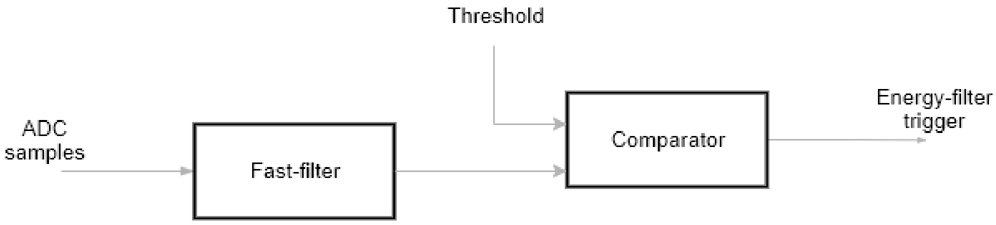
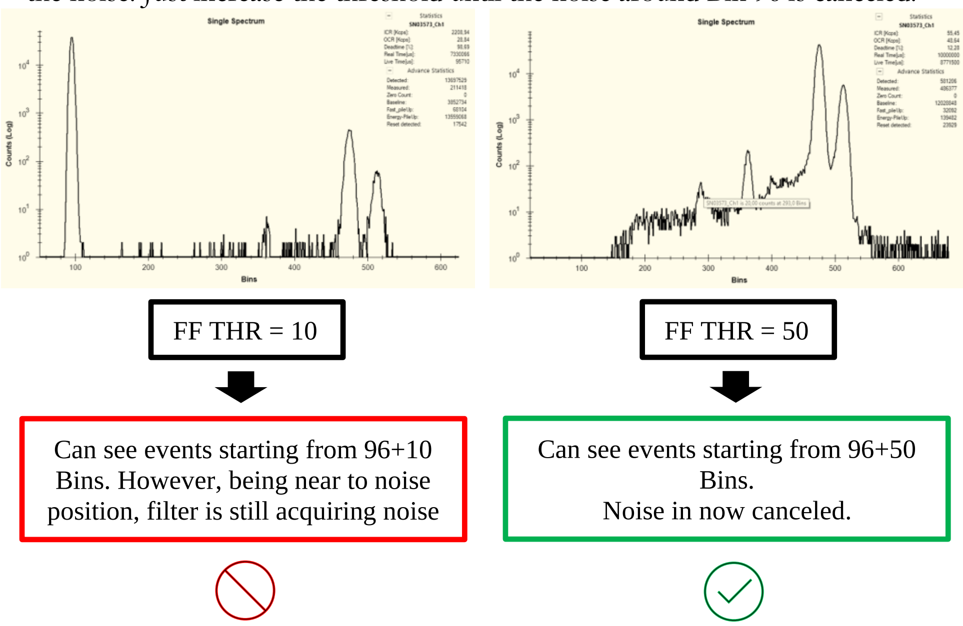


Figure 6.4: Scheme for event detection: if the fast-filter threshold is overcome by the fast-filter output, an event is detected and process by the acquisition chain.

Here below it is explained the procedure to correctly set the Fast-Filter threshold:

- Set *"Zero Peak Rate"* to *'0'* in order to switch off the noise detection.
- Set *"Energy-Filter threshold"* to *'0'* in order to switch off Energy-Filter detection
- Set a low value of the Fast-Filter threshold and acquire a spectra. If there's noise around bin 96, it means that the threshold is too low and the filter is not discarding the noise. Just increase the threshold until the noise around Bin 96 is canceled.



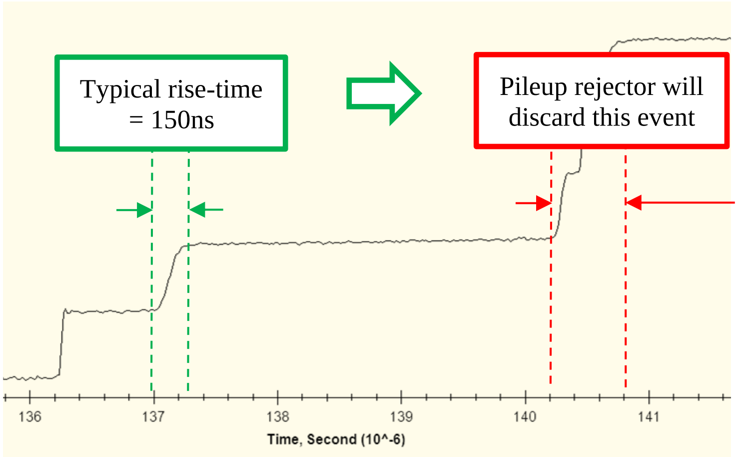
Maximum risetime

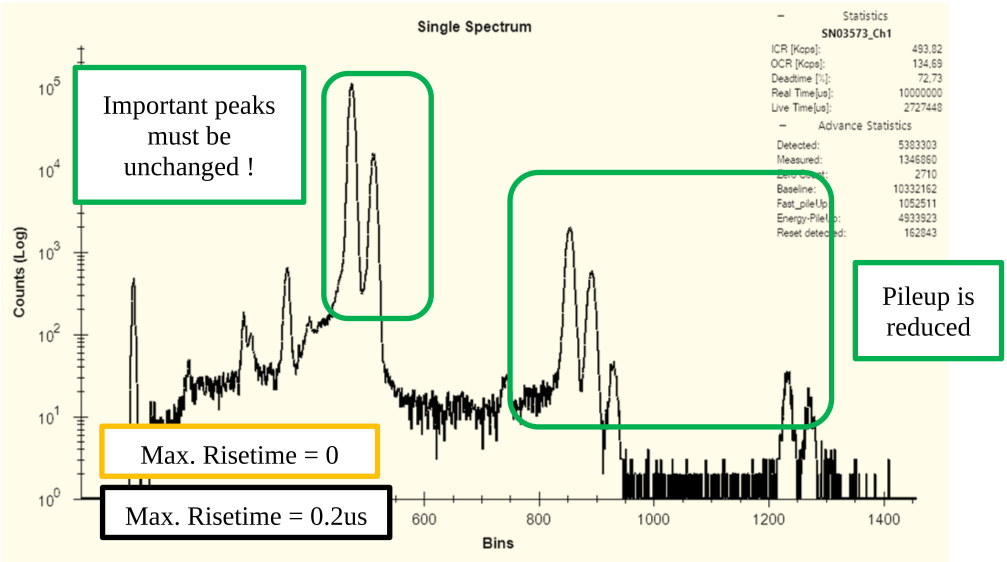
This setting, expressed in 8 ns samples, it's used for the pileup rejection. It has to be set accordingly to the maximum expected risetime of the events from the detector. If the precise risetime is not precisely known we recommend to be conservative and choose a larger number, although if it is set too high pileup rejection would be suboptimal. Inversely, if the maximum risetime is set too low most of the events are discarded as falsely recognized affected by pileup. This can be noted at low input count rates at which pileup are unlikely to occur.

If the maximum risetime is set to 0, the pileup rejection on the fast filter is disabled. The pileup rejection on the main filter (energy filter) instead cannot be currently disabled (that is when two events seen by the fast filter are too near to each other with respect of the energy filter length).

Here below it is shown how to set the Maximum Risetime:

- Set *"Maximum Risetime"* to *'0'*, acquire a spectra and save it.
- Start a waveform and see which is the typical rise-time of the signal. The *"Maximum Risetime"* should be a little bit higher than the one observed.

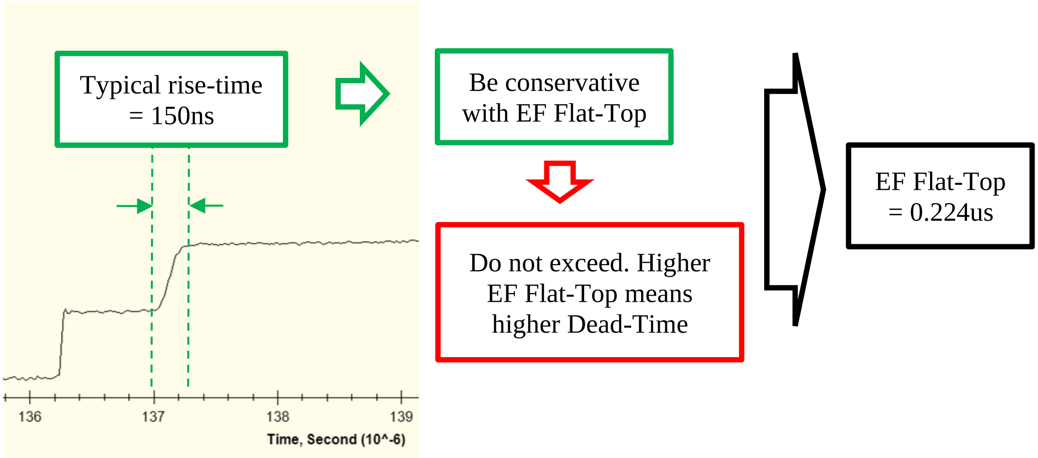




6.3. Energy-Filter Parameters

Peaking-Time, Flat-Top and Threshold

DANTE pulse processing is based on trapezoidal filtering with configurable peaking-time and flat-top. Flat-top duration should account for the maximum expected rise-time of the incoming pulses in order to reduce ballistic deficit.



This is the illustration of the trapezoidal Energy-Filter:

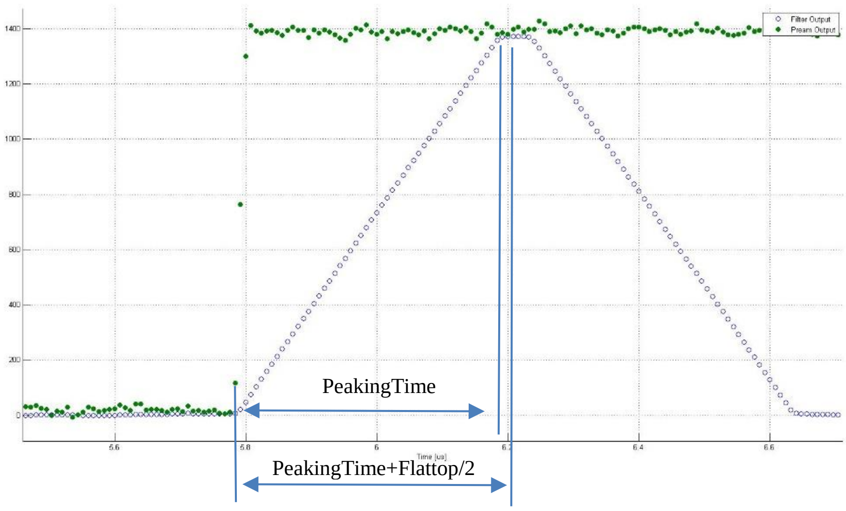
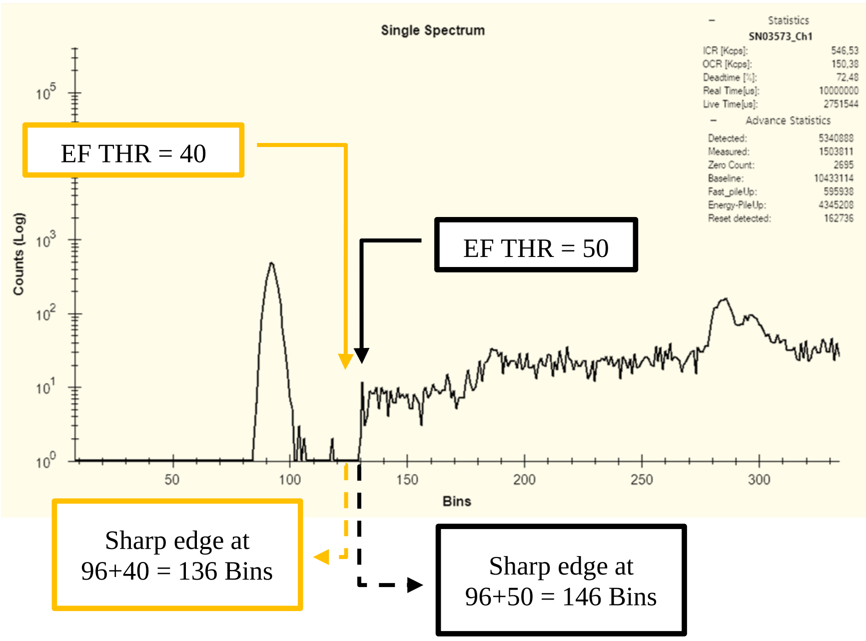


Figure 6.3: Example of trapezoidal filtering shape of the energy filter stage

The low-energy firmware mode, provides an auxiliary threshold which is applied to the energy trapezoidal filter only. The threshold, being applied in the energy filter domain is less senstive to noise and can be used for detecting low-energy event down to Beryllium. One of the major difference with respect to the fast-filter threshold is the possibility for the user to go down with this threshold withouth being completely saturated by the noise of the input signal.



Baseline samples

The baseline sample parameter has to be chosen among this values: 8,16,32,64,128,256,512 (32 ns units). The best setting is equal to the optimal energy filter peaking time (EF Peaking-Time [us] / 0.032us). In fact, the noise of the baseline calculation is similar to the one of the trapezoidal filtering done by the energy filter: if the length is set too low the calculation is very noisy mainly due to white noise contribution, if set too high it again become noisy because of the low frequency noise (1/f).

The precision of the baseline value subtracted is critical to achieve best performances, as noise on this signal would directly degrade the resolution.

For debugging purposes, it is possible to disable the baseline correction by setting baseline samples to 0. This usually lead to optimal energy resolution performances (because nothing is subtracted from the energy filter output, so no noise is added to it) but of course the spectrum will be subject to energies shifts due to temperature or input count rate changes.

Baseline threshold

This is a setting for the baseline correction which should be used in combination with the energy-filter threshold. Standard way to use this parameter is to set is equal or less than the energy-filter threshold. It’s possible to disable it by using value ‘0’.

6.4. High-rate firmware setting

Energy-filter: minimum and maximum Peaking-Time

In high rate mode provides the possibility to configure a minimum and maximum peaking-time. They rapresent the range of possible peaking-time to filter the incoming events: for each event the higher value of the peaking-times to not have the pileup with the adjacent events is chosen.

Please refers to introduction section for more details about the working principle behind the high-rate mode.

When high-rate mode is used, DANTE doesn't allow to use the energy-filter threshold for the low energy events detection.

Energy-filter: flat top

Please note that using the high-rate firmware the parameter should fulfill following requirements:

- flat-top must be an odd number
- Following relation between peaking-time and flat-top must be followed:

$$PeakingTime_{MAX} > \frac{FlatTop}{2} + 1$$

6.5. DPP Statistics

The DPP statistics are provided together with spectrums. They are useful to understand the performance of the acquisition. See DANTE Library API Manual for futher informations.

ICR (Input Count Rate) [Kcps]

Input Count Rate is estimated by the DPP starting by the measured events, real time and deadtime.

OCR (Output Count Rate) [Kcps]

Output Count Rate is computed by the DPP using measured events and real time.

DeadTime [%]

Deadtime indicates the percentage of measuring time (by Energy-Filter) over the total acquisition time. In normal conditions, it has to be about 30%. It increases if a longer filter (Energy-Filter Peaking-Time) is used or count rate increases.

Real Time [us]

Real Time coincides with the total time of the acquisition.

Live Time [us]

Live Time is the total measuring time of the events. It is equal (no events measured) or less than Real Time.

Detected

Events detected only by the Fast-Filter.

Measured

Events measured by the Energy-Filter (valid events, which are not PileUp).

Zero Counts

Number of counts of the noise peak. It is equal or lower than the Zero Peak Rate parameter. Real events have the priority on the zero peak and will not be discarded. For this reason, the maximum number of zero counts strictly depends on Live-Time of the acquisition.

Baseline

Number of baseline samples used for the baseline correction. Depends on Baseline Samples parameter.

Fast_pileUp

Number of events which have been classified as PileUp by the Fast-Filter PileUp rejector. This number depends on the Maximum Risetime parameter.

Energy_pileUp

Total number of events which have been classified as PileUp either by Fast-Filter PileUp rejector or by Energy-Filter (temporal check on event edges).

Reset detected

Total number of resets detected in the acquisition. Depends on Reset Threshold parameter.

XGLab S.R.L. – Bruker Nano Analytics
Via Conte Rosso 23, I-20134 Milano (Italy)

6.6. Parameter Conversion

Respect to the MATLAB-based debug GUI, in the C#-based User Software the parameters have been converted for a more user-friendly visualization.
Here is reported a conversion table for parameters from MATLAB GUI to C# User Software:

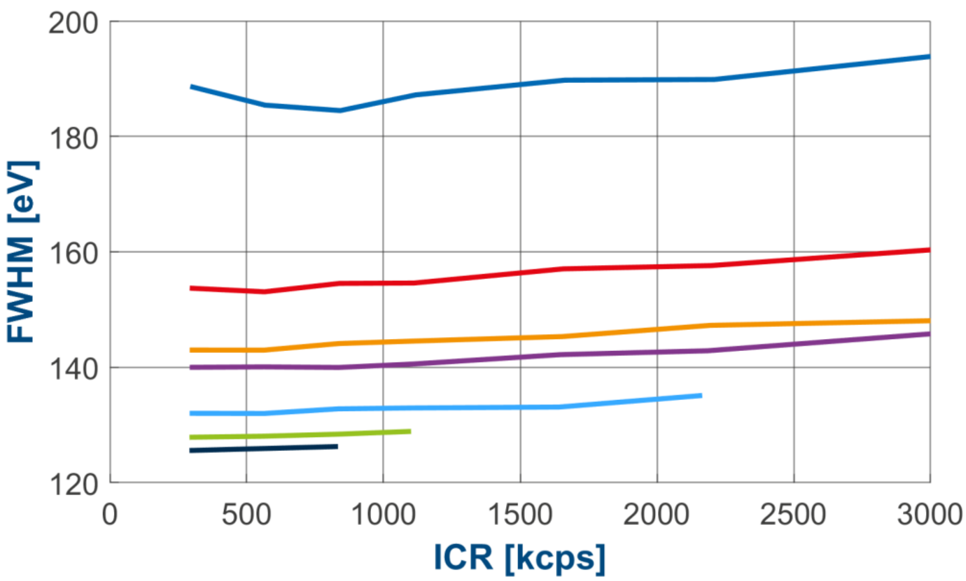
Parameter in Matlab-based debug-GUI	Value in Matlab-based debug-GUI	Parameter in "C#" GUI	Conversion Factor from "MATLAB" GUI to "C#" GUI	Value to be passed in DLL	Conversion Factor from "C#" GUI to DLL
uint32_t **fast_filter_thr**	50 [ADC bin]	Fast Filter Threshold [ADC bin]	equal [ADC bin]	value in [ADC bin]	gui_cs_val
uint32_t **energy_filter_thr**	25 [ADC bin]	Energy Filter Threshold [ADC bin]	equal [ADC bin]	value in [ADC bin]	gui_cs_val
uint32_t **energy_baseline_thr**	25 [ADC bin]	Baseline Threshold	equal [ADC bin]	value in [ADC bin]	gui_cs_val
double **max_risetime**	30 [units]	Max Rise Time [us]	[us] = [units] * 0,008	value in [units]	gui_cs_val / 0,008
double **gain**	1 [units]	Gain	equal [ADC bin]	value in [units]	gui_cs_val
uint32_t **peaking_time**	64 [units]	Energy Filter Peaking Time [us]	[us] = [units] * 0,032	value in [units]	gui_cs_val / 0,032
uint32_t **max_peaking_time**	64 [units]	Energy Filter Max Peaking Time [us]	[us] = [units] * 0,032	value in [units]	gui_cs_val / 0,032
uint32_t **flat_top**	7 [units]	Energy Filter FlatTop [us]	[us] = [units] * 0,032	value in [units]	gui_cs_val / 0,032
uint32_t **edge_peaking_time**	4 [units]	Fast Filter Peaking Time [us]	[us] = [units] * 0,008	value in [units]	gui_cs_val / 0,008
uint32_t **edge_flat_top**	1 [units]	Fast Filter FlatTop [us]	[us] = [units] * 0,008	value in [units]	gui_cs_val / 0,008
uint32_t **reset_recovery_time**	300 [units]	Recovery Time [us]	[us] = [units] * 0,008	value in [units]	gui_cs_val / 0,008
double **zero_peak_freq**	1 [kcps]	Zero Peak Rate [kcps]	equal [kcps]	value in [kcps]	gui_cs_val
uint32_t **baseline_samples**	64 [samples]	Baseline samples	equal [samples]	value in [samples]	gui_cs_val
bool **inverted_input**	Y/N [bool]	Inverted Input	equal [bool]	value in [bool]	gui_cs_val
double **time_constant**	2,2 [us]	Time Constant [us]	[us] = [s] * 10^(-6)	value in [s]	gui_cs_val / (10^6)
uint32_t **base_offset**	0 [ADC bin]	Deconv Offset [ADC bin]	equal [ADC bin]	value in [ADC bin]	gui_cs_val
uint32_t **overflow_recovery**	0 [units]	--	--	0	0
uint32_t **reset_threshold**	1000 [ADC bin]	Reset Thr [ADC bin]	equal [ADC bin]	value in [ADC bin]	gui_cs_val
double **tail_coefficient**	0 [units]	--	--	0	0 (fixed)
uint32_t **other_param**	2 [units]	--	--	2	2 (fixed)

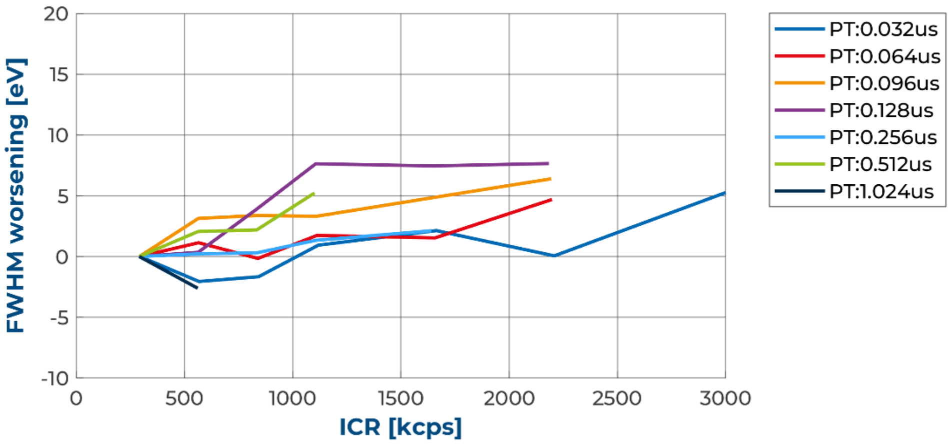
7. Performance examples

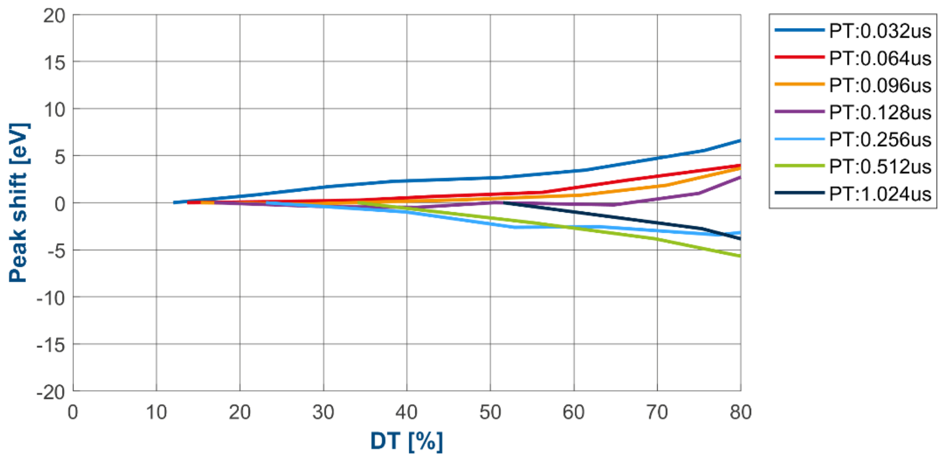
7.1. FWHM Stability

Measurement setup:

- **Firmware**: Low-Energy
- **Sources**: X-Ray tube with Mn(K) foil target (5.9 keV)
- Detector and preamp: 30mm² collimated
- Preamplifier: CUBE
- Temperature: -35°C
- Input Type: DC 10 KOhm
- **Flat top**: 128 ns
- Digital gain: 1
- Reset recovery time: 240ns
- Fast filter peaking time: 8 ns
- Fast filter flat top: 8 ns
- Fast filter threshold: 50 spectrum bins
- Energy filter threshold: 25 spectrum bins
- Max risetime: 160 ns
- Baseline samples: 64



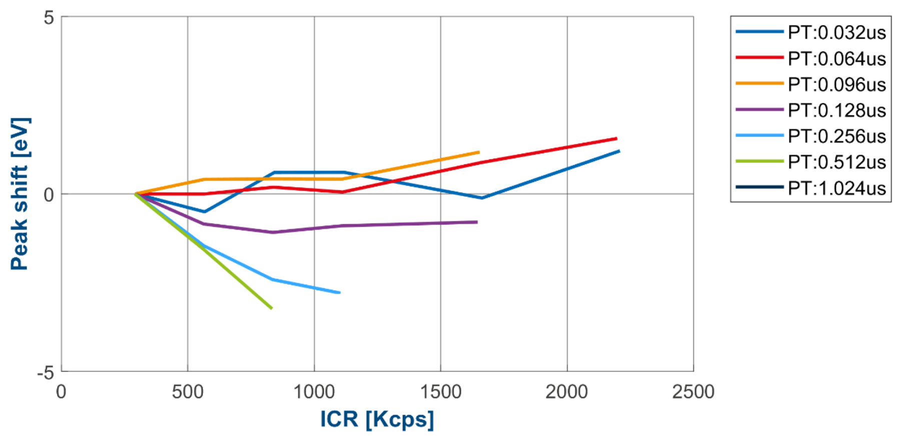

FWHM worsening [eV]
ICR [kcps]
20
15
10
5
0
-5
-10
0
500
1000
1500
2000
2500
3000
PT:0.032us
PT:0.064us
PT:0.096us
PT:0.128us
PT:0.256us
PT:0.512us
PT:1.024us

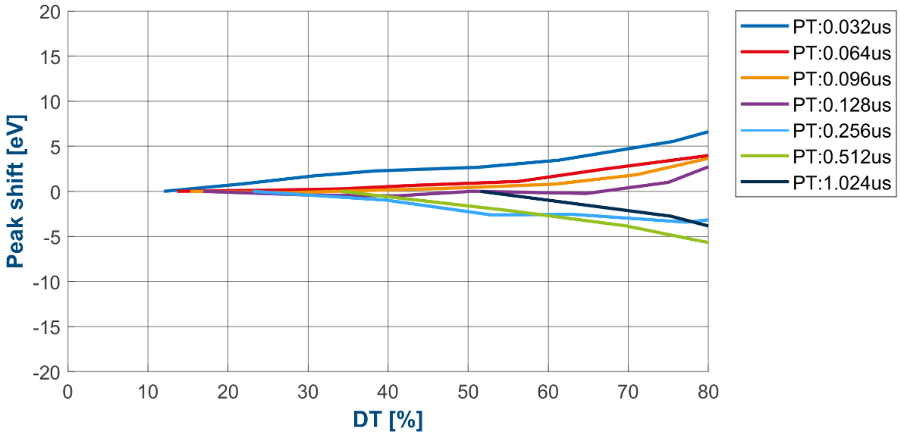

Peak shift [eV]
DT [%]
20
15
10
5
0
-5
-10
-15
-20
0
10
20
30
40
50
60
70
80
PT:0.032us
PT:0.064us
PT:0.096us
PT:0.128us
PT:0.256us
PT:0.512us
PT:1.024us

7.2. Peak Stability

Measurement setup:

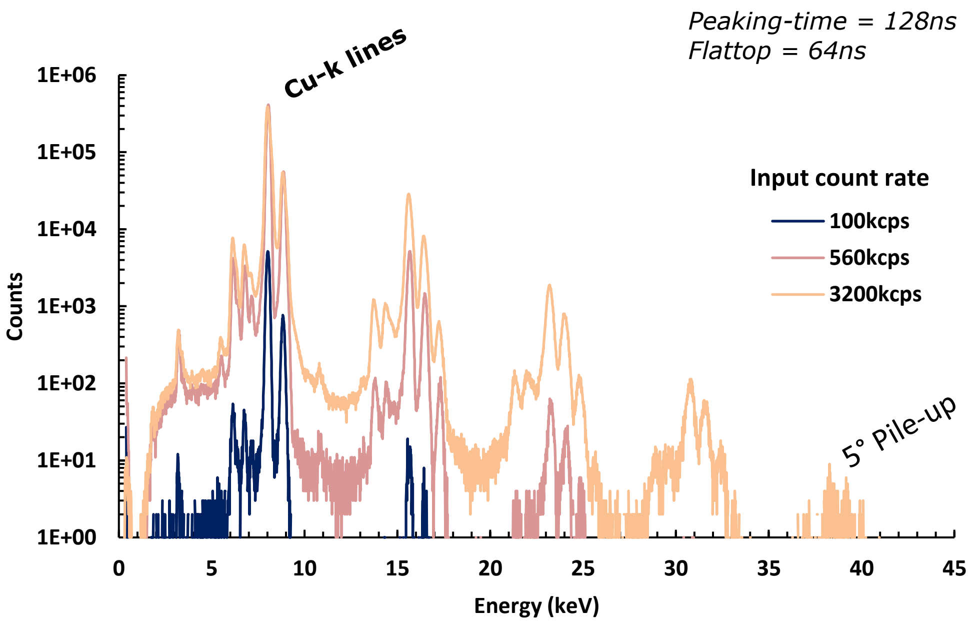
- **Firmware**: Low-Energy [LE]
- **Sources**: X-Ray tube with Mn(K) foil target (5.9 keV)
- Detector and preamp: 30mm² collimated
- Preamplifier: CUBE
- Temperature: -35°C
- Input Type: DC 10 KOhm
- Flat top: 96 ns
- Digital gain: 1
- Reset recovery time: 240ns
- Fast filter peaking time: 8 ns
- Fast filter flat top: 8 ns
- Fast filter threshold: 50 spectrum bins
- Energy filter threshold: 25 spectrum bins
- Max risetime: 160 ns
- Baseline samples: 64





7.3. Pile-up

In this section, results of the the pile-up rejection characterization are shown. The following figure gives an overview of the achievable performances.



A common approach used to compare pile-up performances among different DPP systems is based on time-resolution, which can be evaluated from the ratio P2P1 (ratio between the area of the double-peak and the single-peak). Time resolution is dependent on the the P2P1 with the following relationship:

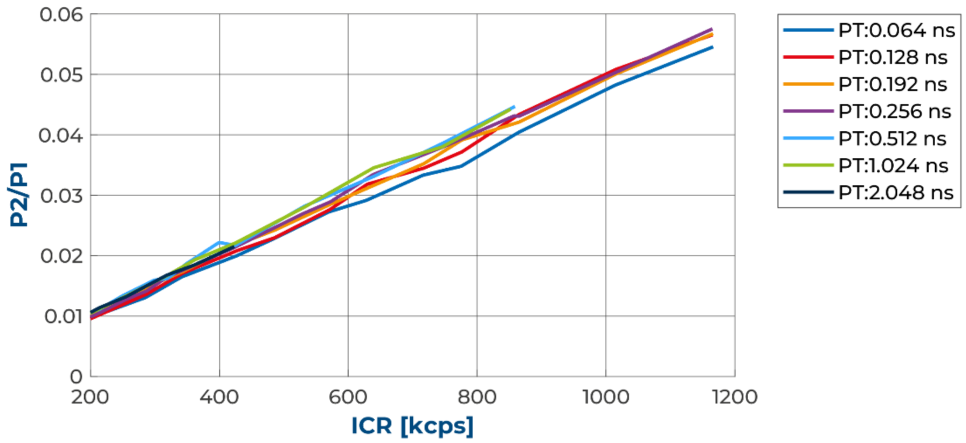
$$P2P1 = ICR \times \tau / 2$$

Lower P2P1 means better time-resolution and better pile-up rejection performances.

The following graph shows the P2P1 for different ICR and peaking-time. The following data have been acquired through an XRF acquisition with an X-Ray tube with a Mn(K) foil target.

Measurement setup:

- **Sources**: X-Ray tube with Mn(K) foil target (5.9 keV)
- Detector and preamp: VORTEX-ME4 SDD
- Temperature: -38°C
- Input Type: DC 10 KOhm
- **Flat top**: 128 ns
- Digital gain: 3
- Reset recovery time: 2 us
- Fast filter peaking time: 64 ns
- Fast filter flat top: 8 ns
- Fast filter threshold: 100 spectrum bins
- Max risetime: 112 ns
- Baseline samples: 64



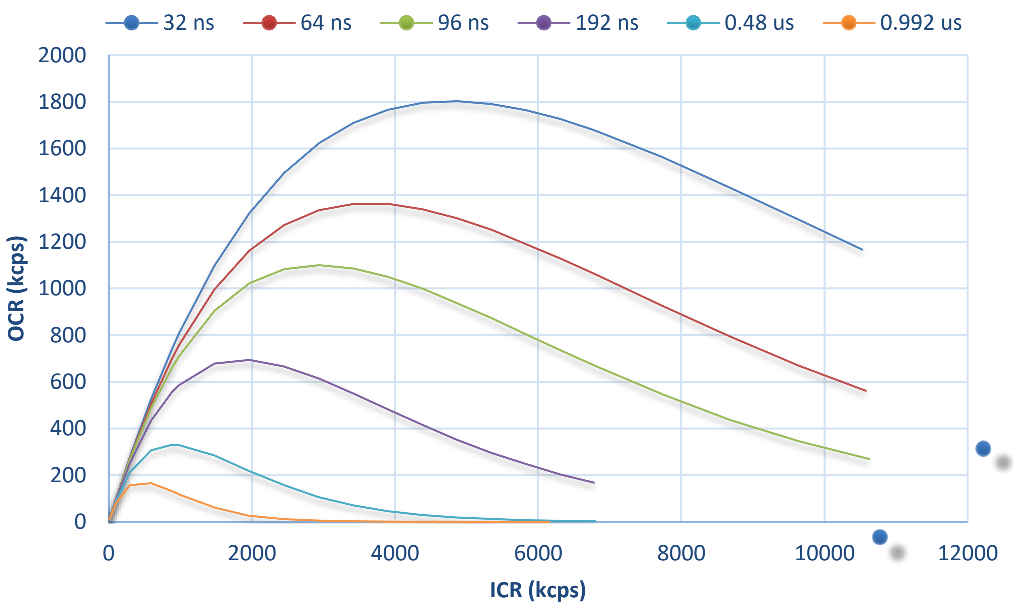
7.4. OCR vs ICR

This section shown the achievable performance at high count rates, characterized by acquiring emulated randomly distributed monoenergetic events. Two characterizations are presented here:

- OCR vs ICR using an emulation of randomly distributed monoenergetic events
- OCR vs ICR by an XRF acquisition using X-Ray tube with a Fe sample

Emulated spectrum setup:

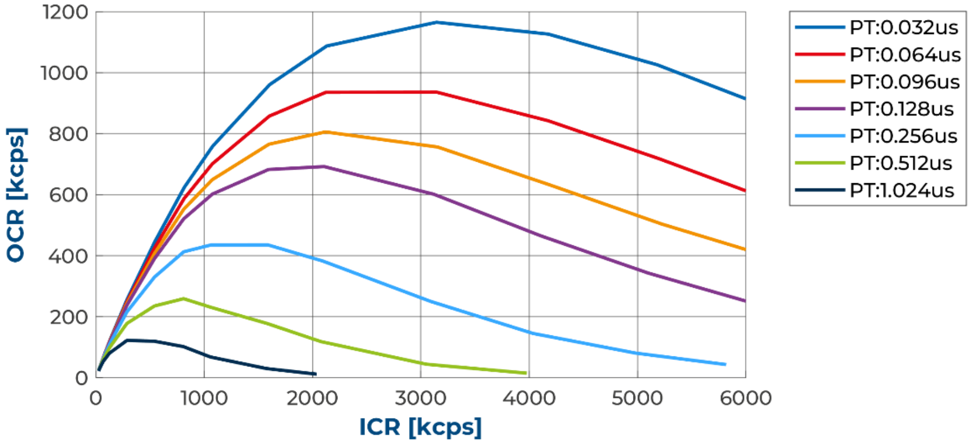
- Flat top: 64 ns
- Fast filter threshold: 100 spectrum bins
- Digital gain: 1
- Reset recovery time: 0.48 µs
- Fast filter peaking time: 8 ns
- Baseline samples: 64



Measurement setup:

- **Sources**: X-Ray tube with Mn(K) foil target (5.9 keV)
- Detector and preamp: 30mm² collimated
- Preamplifier: CUBE
- Temperature: -35°C
- Flat top: 96 ns
- Digital gain: 1
- Reset recovery time: 240ns
- Fast filter peaking time: 8 ns

- Fast filter flat top: 8 ns
- Min energy peaking time: variable
- Max energy peaking time: 3us
- Fast filter threshold: 50 spectrum bins
- Energy filter threshold: 25 spectrum bins
- Max risetime: 160 ns
- Baseline samples: 64

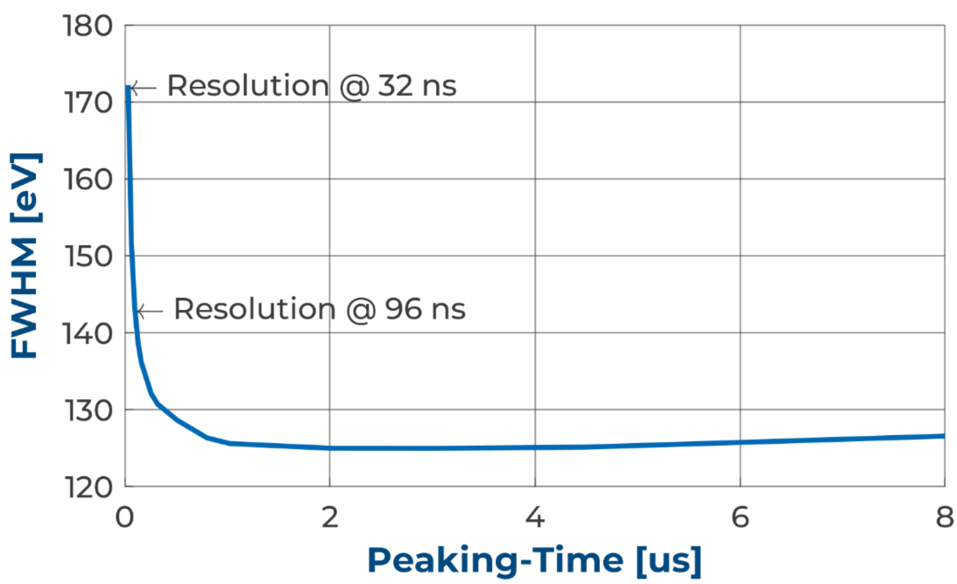


7.5. Energy resolution

This section presents the achievable performance in terms of energy resolution. These measurements have been performed with the following setup and settings:

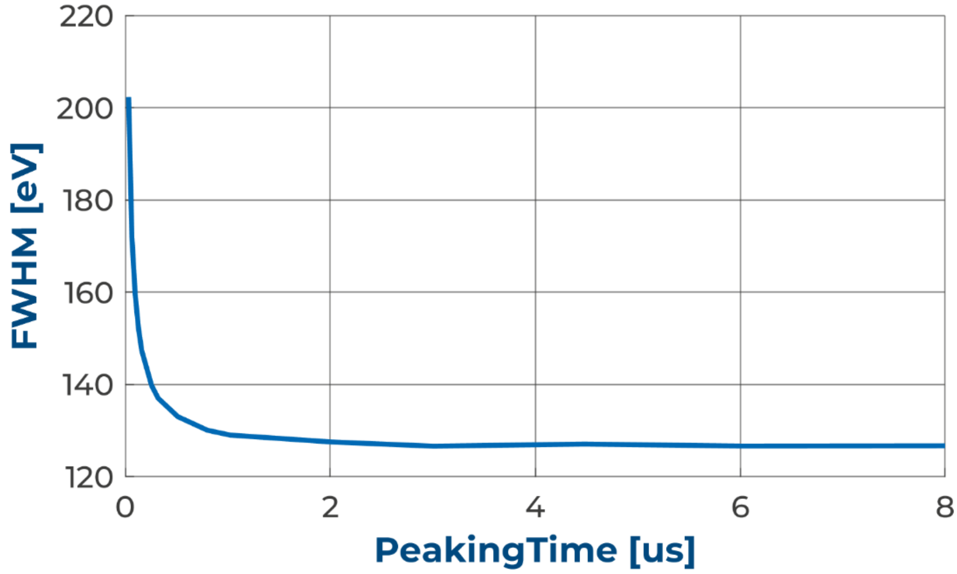
Measurement setup:

- **Sources**: Mn(K) source (5.9 keV)
- **Detector and preamp**: 30mm² collimated
- **Preamplifier**: CUBE, preamplifier gain 7mv/keV
- Temperature: -35°C
- Input Type: DC 10 KOhm
- **Flat top**: 128 ns
- Digital gain: 1
- Reset recovery time: 240ns
- Fast filter peaking time: 32 ns
- Fast filter flat top: 8 ns
- Fast filter threshold: 50 spectrum bins
- Energy filter threshold: 25 spectrum bins
- Max risetime: 160 ns
- Baseline samples: 64



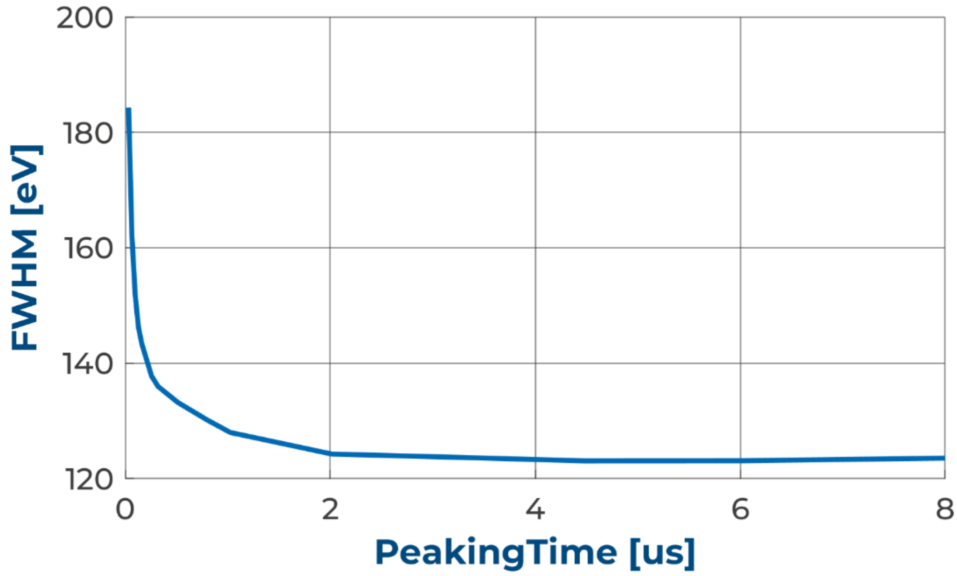
Measurement setup:

- **Source**: Fe55
- **ICR**: 100 kcps
- **Detector**: XR-100-FAST SDD
- **Preamplifier**: Cube (5mV/keV)
- Temperature: -38°C
- Input Type: DC 10 KOhm
- Digital gain: 1
- Reset recovery time: 2.4 us
- Fast filter peaking time: 32 ns
- Fast filter flat top: 8 ns
- Fast filter threshold: 100 spectrum bins
- Max risetime: 240 ns
- Energy filter flat top: 224 ns
- Energy filter threshold: 50 spectrum bins
- Baseline samples: 64



Measurement setup:

- **Source**: Fe55
- **ICR**: 20 kcps
- **Detector**: 7 mm2 Ketek's VITUS SDD collimated
- **Preamplifier**: CUBE PRE_016 (5mV/keV)
- Temperature: -38°C
- Input Type: DC 10 KOhm
- Digital gain: 1
- Reset recovery time: 2.4 us
- Fast filter peaking time: 32 ns
- Fast filter flat top: 8 ns
- Fast filter threshold: 50 spectrum bins
- Max risetime: 240 ns
- Energy filter flat top: 224 ns
- Energy filter threshold: 25 spectrum bins
- Baseline samples: 64

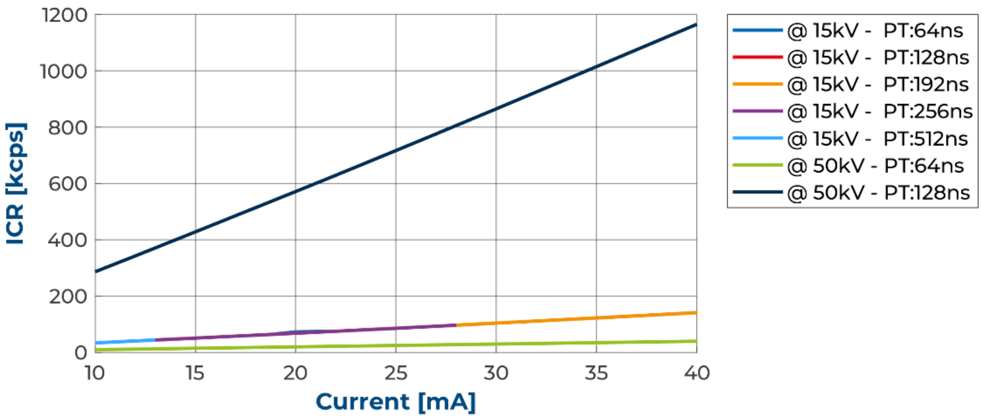


7.6. ICR Linearity

This section illustrates the ICR linearity performance at high count rates. To obtain the following data, an XRF measurement has been done using an X-Ray tube with a Mn(K) foil target.

Measurement setup:

- **Sources**: X-Ray tube with Mn(K) foil target (5.9 keV);
- Detector and preamp: VORTEX-ME4 SDD;
- Temperature: -38°C;
- Input Type: DC 10 KOhm
- **Flat top**: 128 ns;
- Digital gain: 3;
- Reset recovery time: 2 us;
- Fast filter peaking time: 64 ns;
- Fast filter flat top: 8 ns;
- Fast filter threshold: 100 spectrum bins;
- Max risetime: 112 ns;
- Baseline samples: 64;

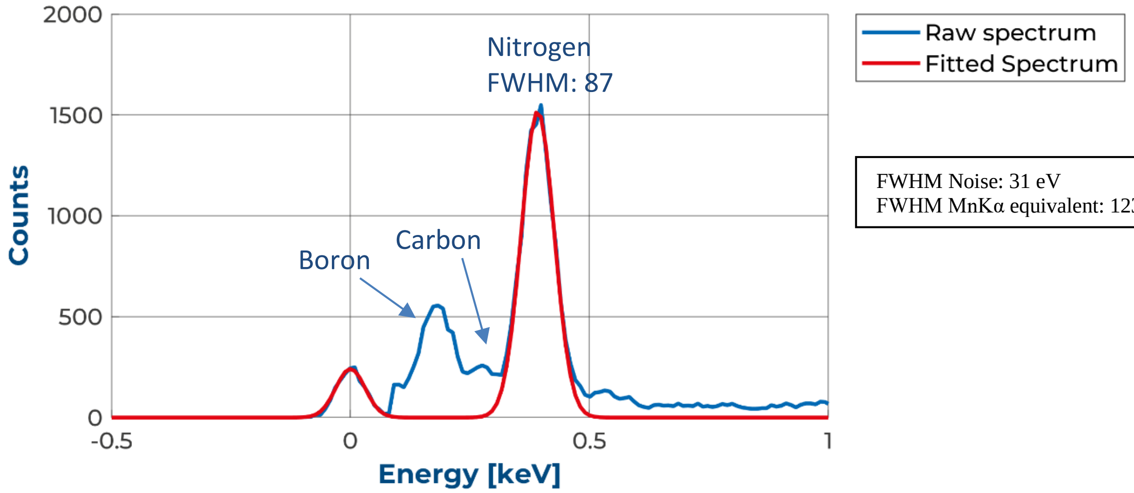


7.7. Light element efficiency

Performance achiavable in the low-energy detection are here presented. The set-up involves the use of a SEM and light sample elements.

Boron-Carbon-Nitrogen sample setup:

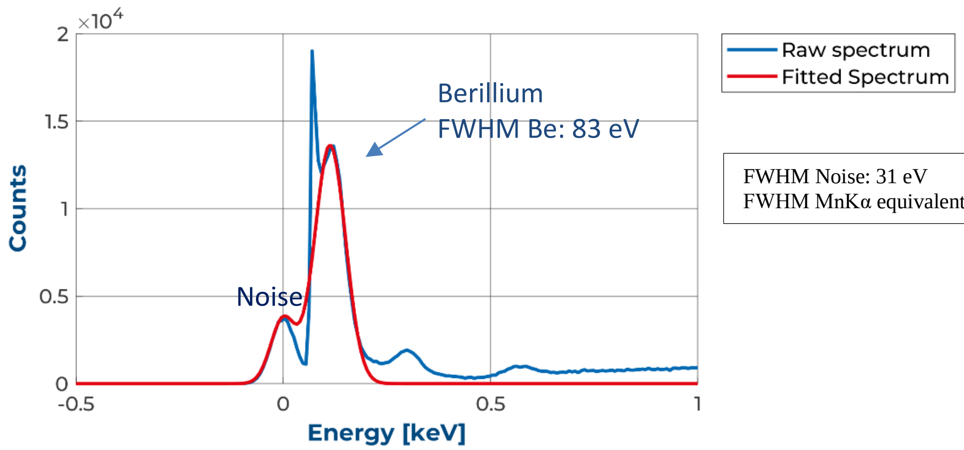
- **Sources**: Boron-Carbon-Nitrogen sample
- Detector and preamplifier: Bruker X-Flash
- Temperature: -38°C
- Input Type: DC 10 KOhm
- Digital gain: 1
- Reset recovery time: 4 us
- Fast filter peaking time: 120 ns
- Fast filter flat top: 8 ns
- Fast filter threshold: 100 spectrum bins
- Max risetime: 240 ns
- Energy filter peaking time: 2.56 us
- Energy filter flat top: 224 ns
- Energy filter threshold: 14 spectrum bins
- Baseline samples: 64



FWHM Noise: 31 eV
FWHM MnKα equivalent: 123 eV

Beryllium sample setup:

- **Sources**: Be sample
- Detector and preamplifier: Bruker X-Flash
- Temperature: -38°C
- Input Type: DC 10 KOhm
- Digital gain: 1.5
- Reset recovery time: 2.4 us
- Fast filter peaking time: 32 ns
- Fast filter flat top: 8 ns
- Fast filter threshold: 100 spectrum bins
- Max risetime: 240 ns
- Energy filter peaking time: 1.6 us
- Energy filter flat top: 224 ns
- Energy filter threshold: 11 spectrum bins
- Baseline samples: 64



FWHM Noise: 31 eV
FWHM MnKα equivalent: 123 eV

8. Application examples

8.1. Mapping

Mapping capabilities of DANTE DPP are here presented. The following measurement has been performed at the ELETTRA synchrotron (TwinMic beamline). Target of the experiment was the study of the Fe and Co concentration within a biological cells.

For this measurement DANTE has been configured in order to perform free-running map scan with a fixed time per spectrum of 100 ms. The external gating signal has been used to reconstruct the spectrum of each pixel.

Map settings:

- Acquisition time: 13.4 hours
- **Pixels**: 270 x 270
- Step size: 0.18um
- **Time**: 0.6s/pixel
- **Dead time:** 0.05s/pixel due to motor movement

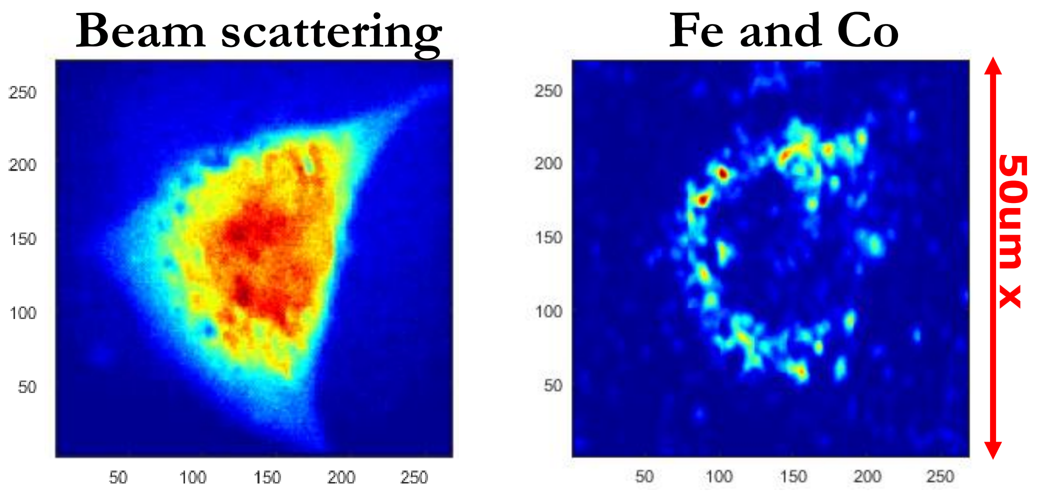


Figure 8.1: (left) Scattered beam distribution within the cell. (right) Fe and Co concentration

8.2. XAS Spectroscopy

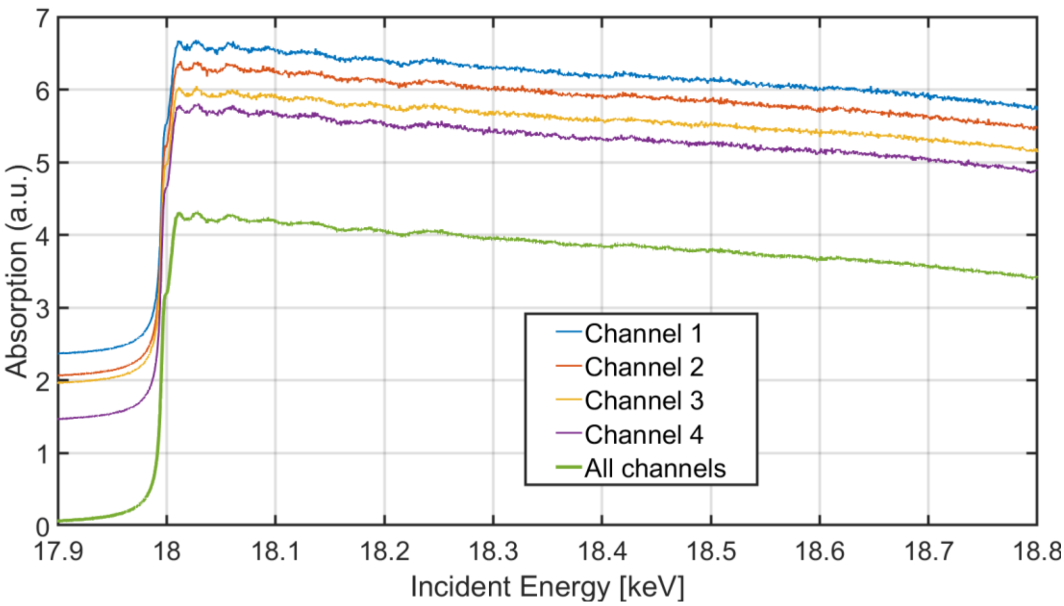
DANTE mapping mode is suitable for XAS spectroscopy measurements which is used to evaluate the x-ray absorption coefficient of a given material as a function of the incident x-ray energy.

By changing the input incident x-ray energy, the change in the transmitted x-ray intensity can be recorded by DANTE. If the incident energy sweep is correlated with a gating/triggering signal, the mapping mode can be used to provide all the synchronized transmitted spectra.

We present here the results of an EXAFS measurement thanks to a collaboration with the DESY synchrotron.

XAS setup:

- **DPP**: DANTE 8CH with only 4 channels active
- Material: Zirconium
- Incident energy: 17.8 keV to 19 keV
- **Frame rate:** 6 Hz (about 150 ms per spectrum)



9. Revisions

Rev 2.7: Corrected formula for Time resolution, added indication of Input Type in the performance examples.
Rev 2.6: unified with Acquisition Software manual and added Sweep acquisition mode
Rev 2.5: added section on installation; added CE markings
Rev 2.4: added section on Safety norms and instructions
Rev 2.3: some graphics updated.
Rev 2.2: Energy-timestamp mode: energy threshold and zero peak must be disabled for correct 8ns timestamp resolution. High-rate firmware supports 32ns timestamp resolution only.
Rev 2.0: new set of measurements.

CE

XGLab S.R.L. – Bruker Nano Analytics
Via Conte Rosso 23, I-20134 Milano (Italy)