XGLAB
X and Gamma Ray Electronics

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OBJECT: DANTE-4553 User Manual
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1. Overview

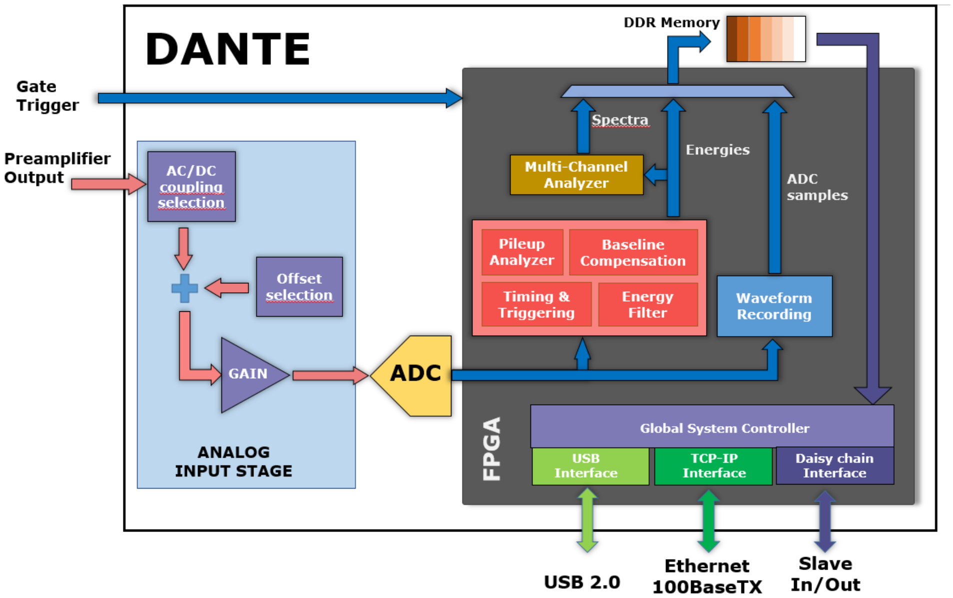


Figure 1.1: Main DANTE DPP scheme

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.

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
OCR vs. ICR linearity	Dead-time < 70%	3%
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)[2]	$P2P1 = \sqrt{2 \times ICR \times \tau}$	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, … E_i t_1, t_2, … t_3	16-bit resolution 8 ns resolution

[1] **Test Conditions:** Detector SDD 30 mm^2, CUBE ASIC, preamplifier gain 7mV/keV, Temp = -35 °C, Flattop = 160 ns, ICR = 20 kcps, Irradiation source = ^{55}Fe.
[2] **Time resolution:** P2P1 is the ratio between the double peak and the single peak of the spectrum.

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	2 µs
AC fast	1 kOhm	22 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
Control system		TANGO, EPICS

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. 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.

3.1 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.

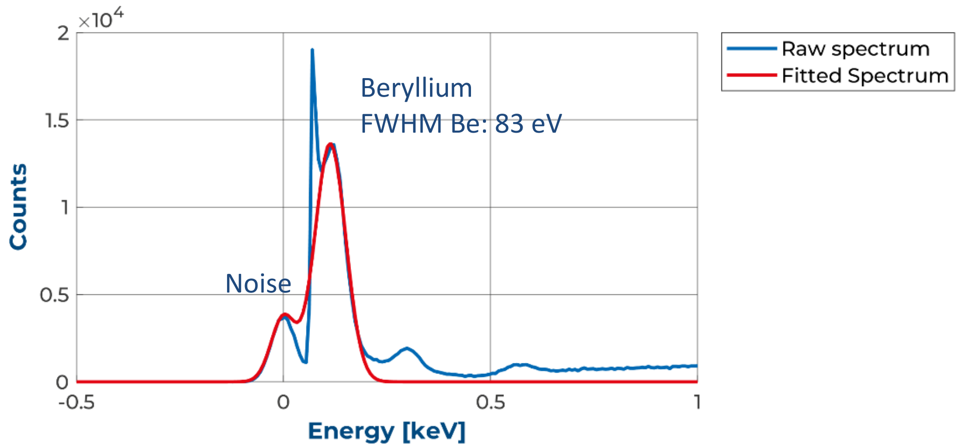


Figure 3.1: Achievable spectrum with Be sample and low-energy firmware.

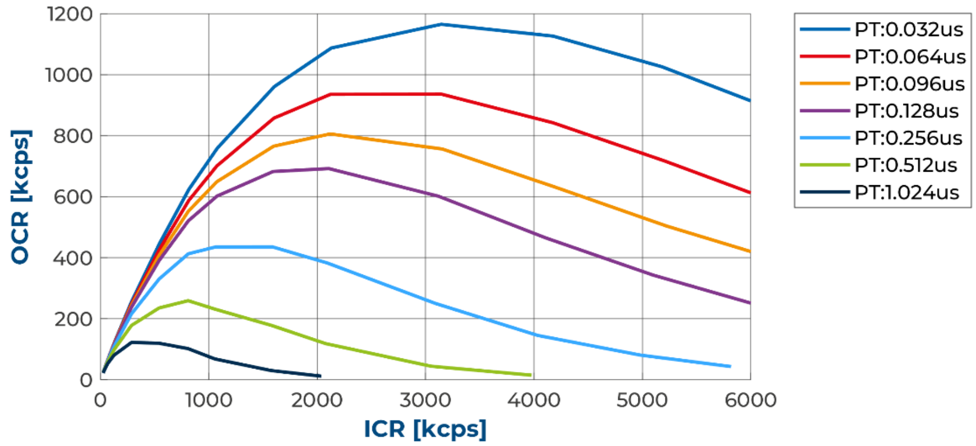


Figure 3.2: OCR vs ICR performances with 96ns flat-top

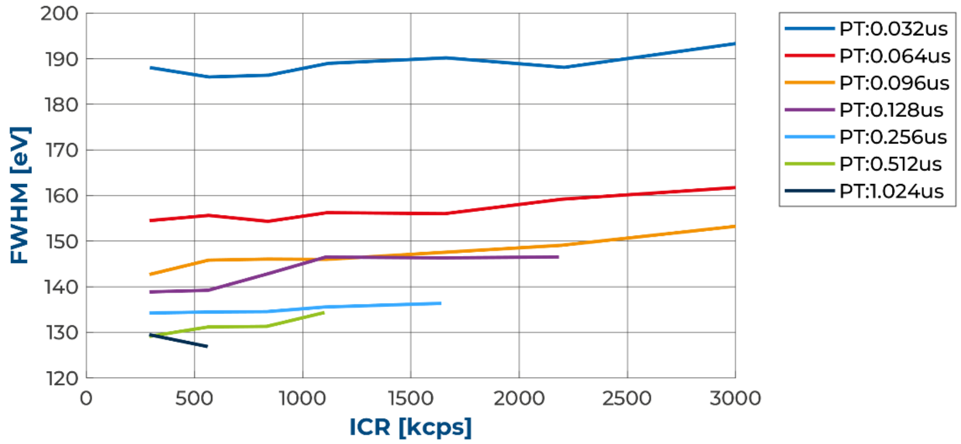


Figure 3.3: Stability of FWHM at different ICR for the low-energy firmware.

3.2 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.

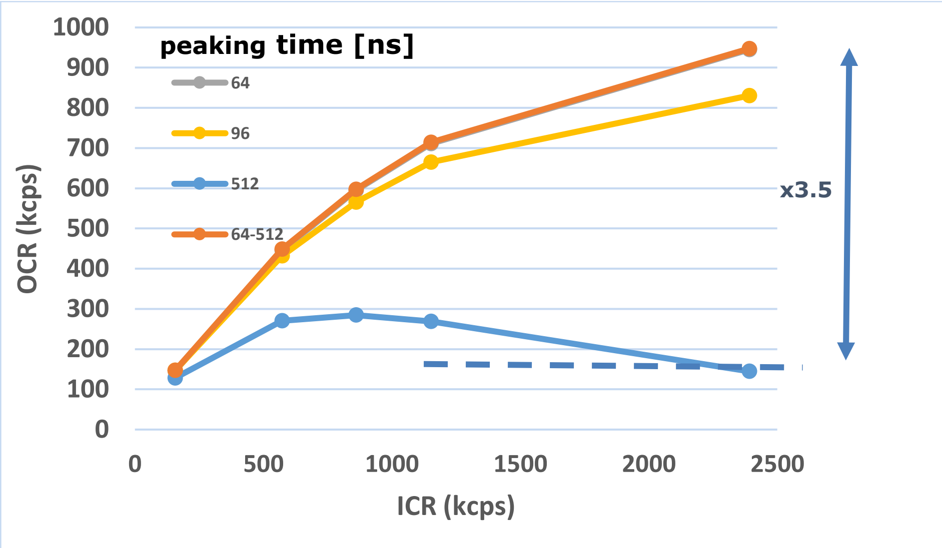


Figure 3.4: OCR vs ICR curve. High-rate mode allows to maximize OCR performance. Please note that grey curve (std-64ns) and orange curve (64ns - 512ns) are superimposed.

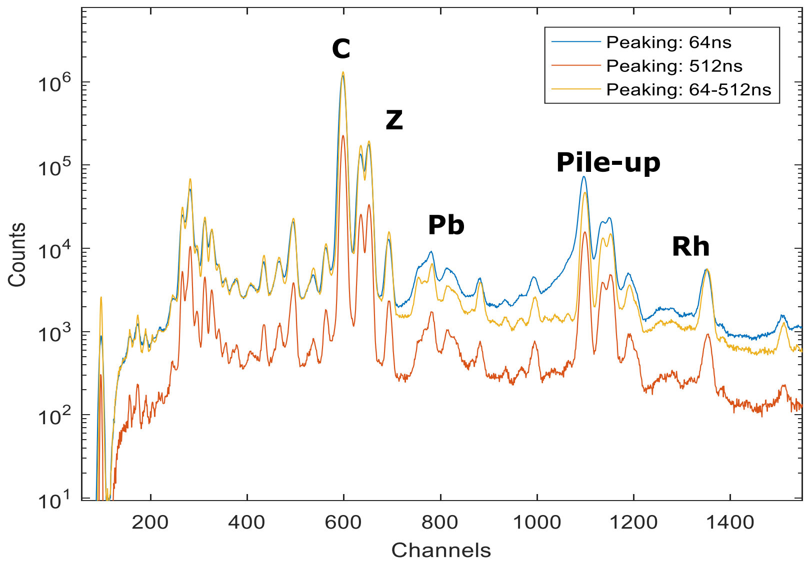


Figure 3.5: Comparison of spectra quality in standard-mode or high-rate mode.

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.

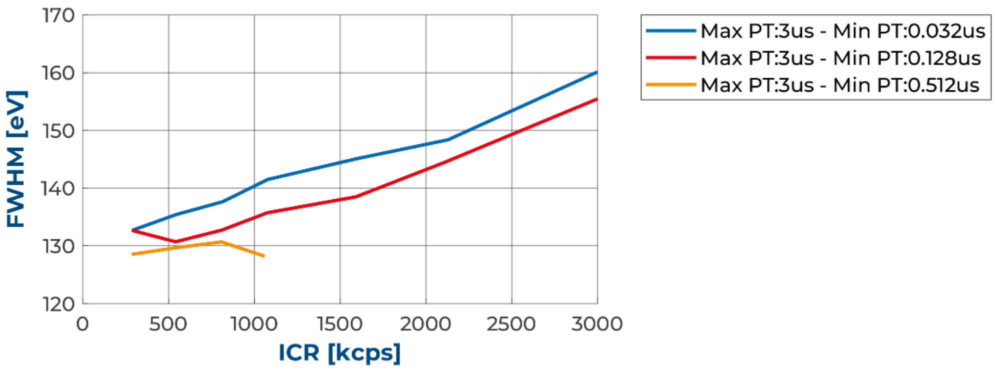


Figure 3.6: FWHM trend vs ICR in HR firmware.

4. Acquisition modes

4.1 Scanner (waveform) mode

Scanner 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:

- **Length**: acquisition of waveform up to 500ms at full sampling frequency.
- **Decimation**: possibility to reduce sampling frequency for saving waveform longer than 500ms.
- **Triggers and threshold**: triggering the acquisition on a specific events like the reset of the ramp.

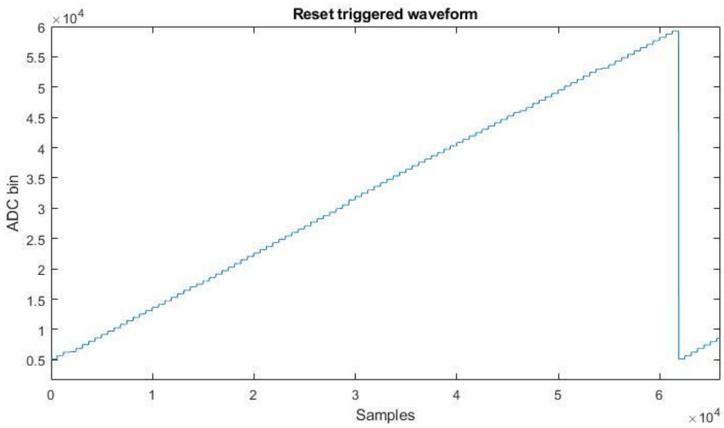


Figure 4.1: Example of waveform acquired configuring the trigger to detect reset event.

4.2 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.

4.3 Mapping mode

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

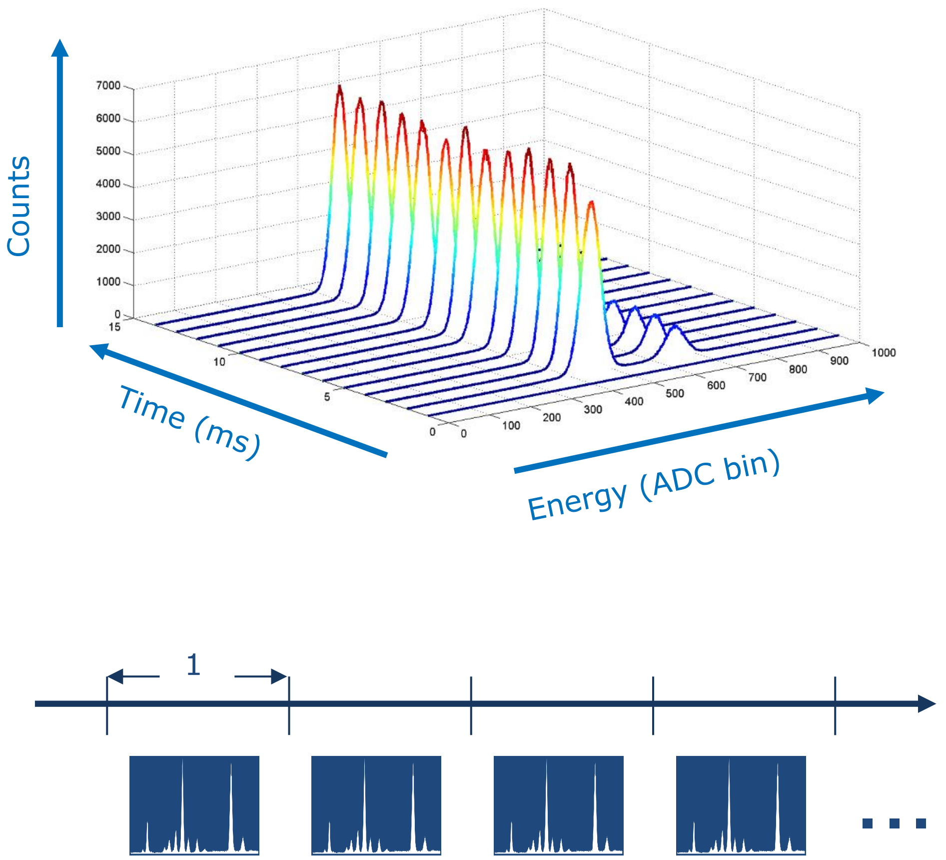


Figure 4.2: continuous acquisition of spectra down to 1ms with zero dead time between spectra

DANTE DPP can be configured to acquire accordingly to an external logic input 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 elapses.
- **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.

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

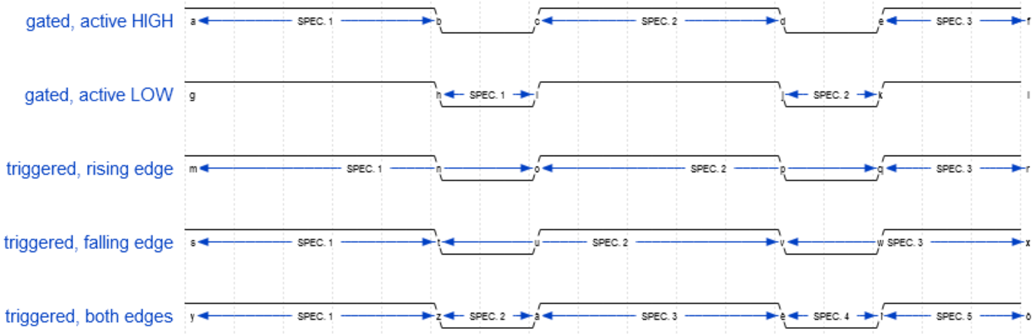


Figure 4.3: Gating – trigger modes supported by DANTE.

The minimum spectrum time achievable by the mapping mode is affected by the number of channel connected to a single USB-TCP/IP connection. Considering N channels controlled by a single USB-TCP/IP connection, the minimu spectrum time is given by:

$$SPtime_{min} \approx 1\,ms \cdot N$$

4.4 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.

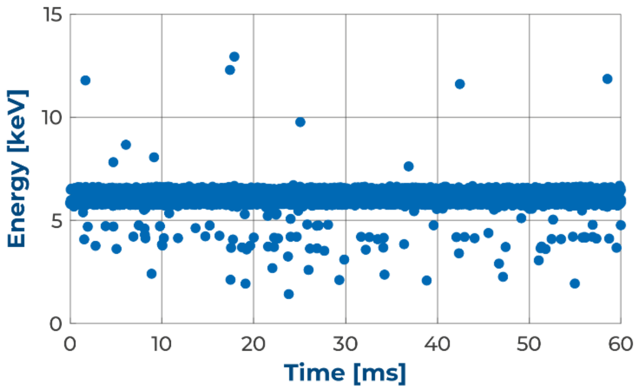


Figure 4.4: real-time throughput of energy and timestamp for each photon event with 8ns precision

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 GUI or library manual for further details about the statistics and error.

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 threshold by putting value ‘0’. For the same reason, for energy-timestamp analysis only, the zero-peak should be disabled.

High-rate firmware supports 32ns timestamp resolution only.

4.5 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. A default value of 4.8us should allow to see the edge of the recorded events.

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.

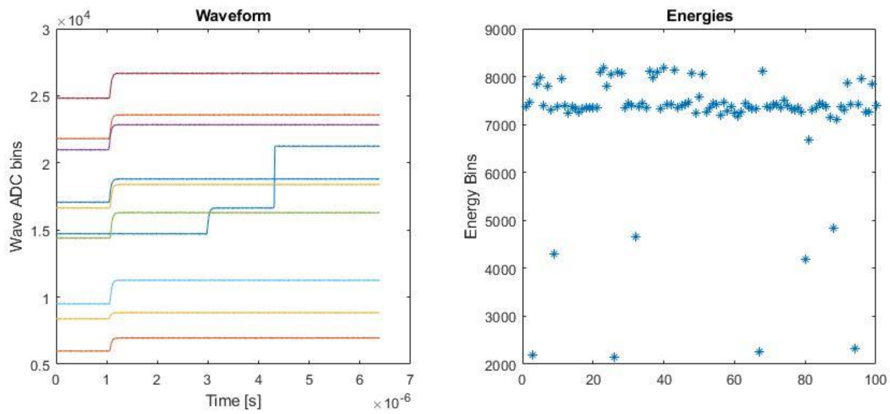


Figure 4.5: (left) waveform for each recorded event. (right) energy of each event.

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. Parameters definition

5.1 Input configuration

Front-end configuration

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 base-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. Base-offset and time-costant are needed to deconvolve the input signal correctly.

- **base-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.

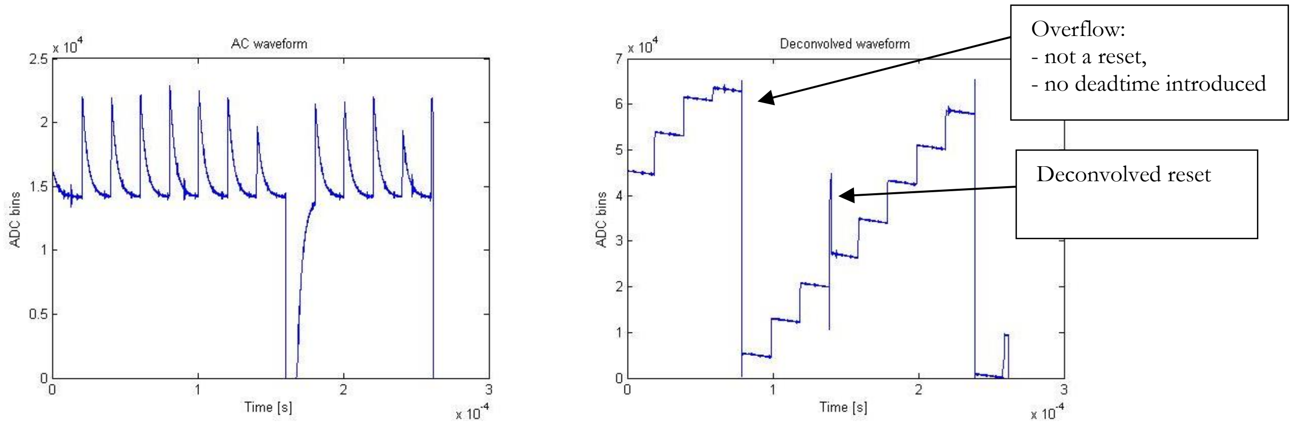


Figure 5.1: (left) waveform with exponential pulses. (right) deconvolved waveform

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.

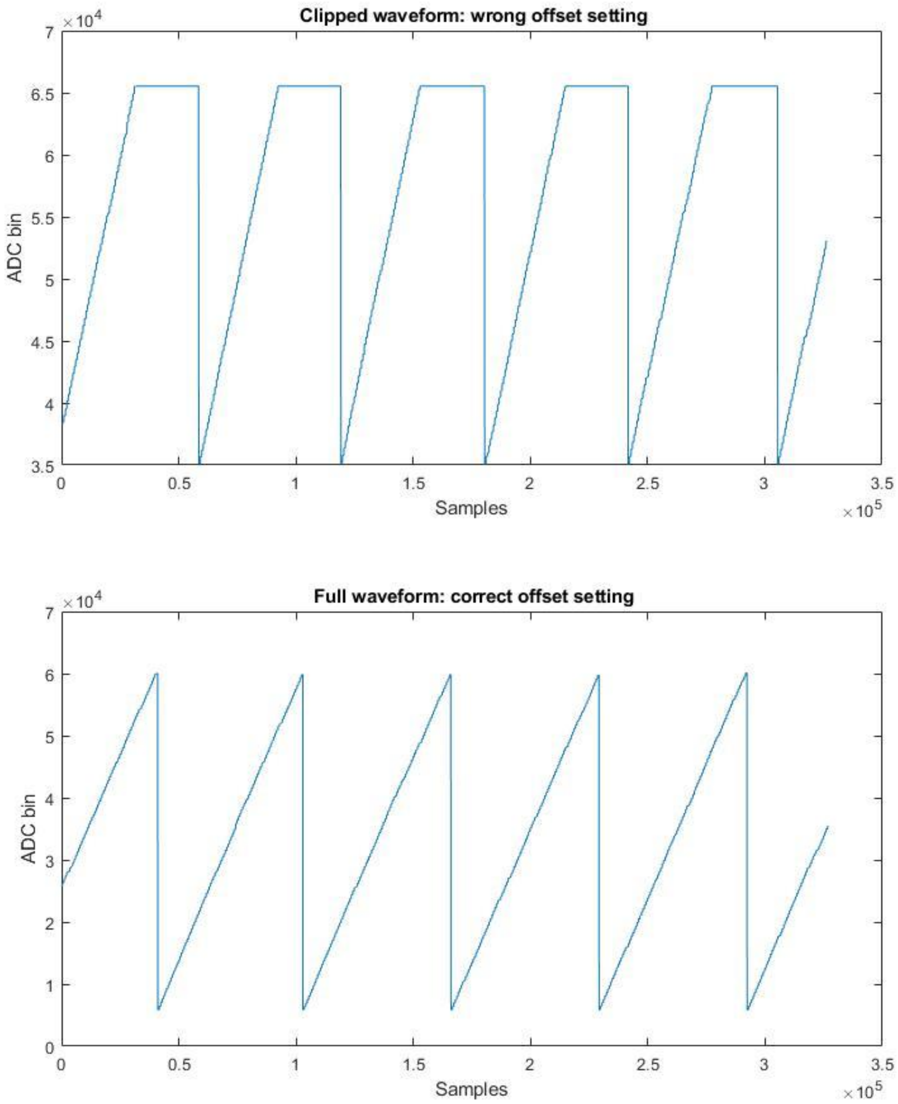


Figure 5.2: (top) Saturated waveform due to a wrong offset setting. (bottom) waveform correctly centered into the ADC dynamic-range after offset calibration.

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.

5.2 DPP Configuration

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.

Energy-filter peaking-time and 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.

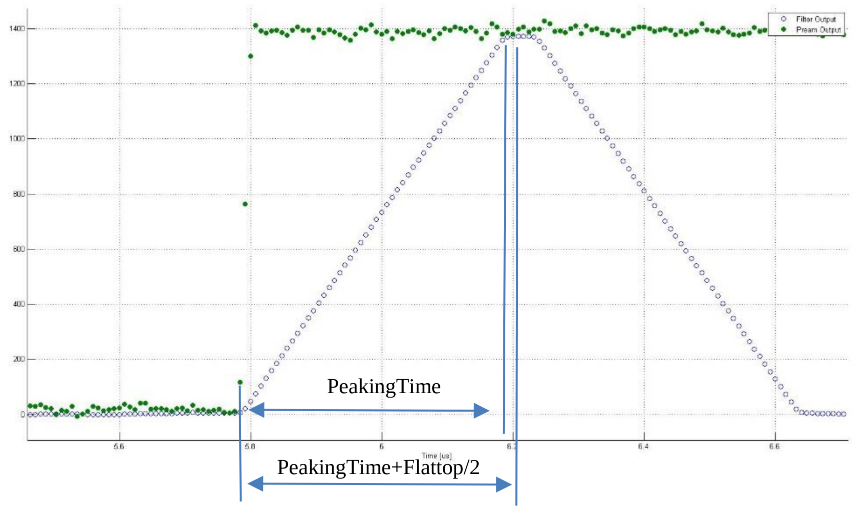


Figure 5.3: Example of trapezoidal filtering shape of the energy filter stage

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.

Fast-filter: peaking-time, flattop and threshold

Standard detection of events is done by a combination of the fast-filter 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, both peaking time and gap can be selected for the fast filter but are expressed in unit of 8ns.

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.

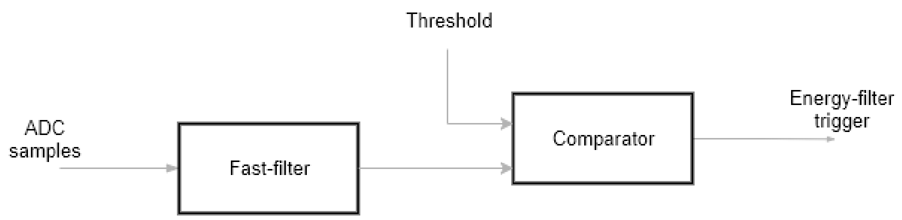


Figure 5.4: Scheme for event detection: if the fast-filter threshold is overcome by the fast-filter output, an event is detected and process by the acquisition chain.

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. Real events have the priority on the zero peak and will not be discarded.

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).

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. 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'.

Reset threshold

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

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

Recovery time

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

5.3 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:

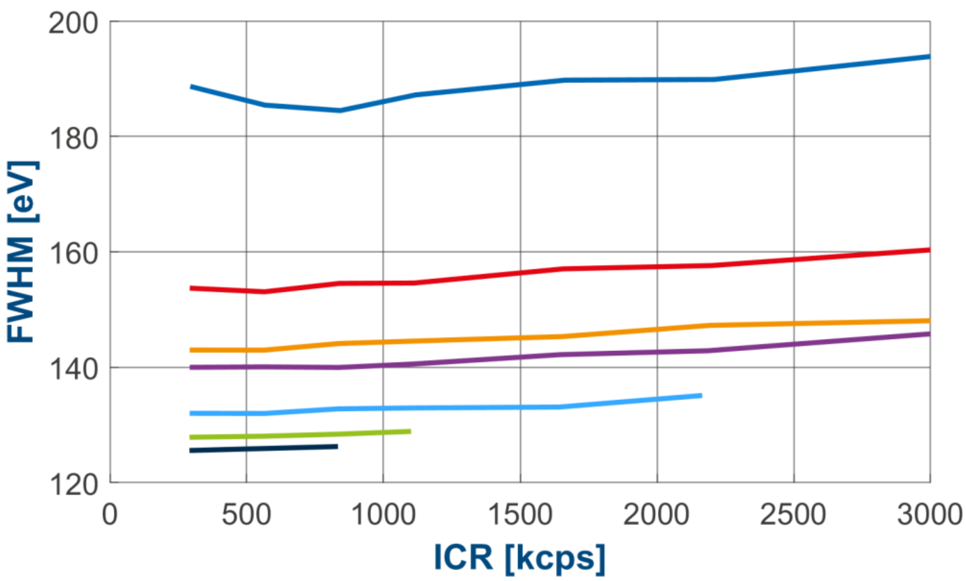
$$PeakingTime_{MAX} > \frac{FlatTop}{2} + 1$$

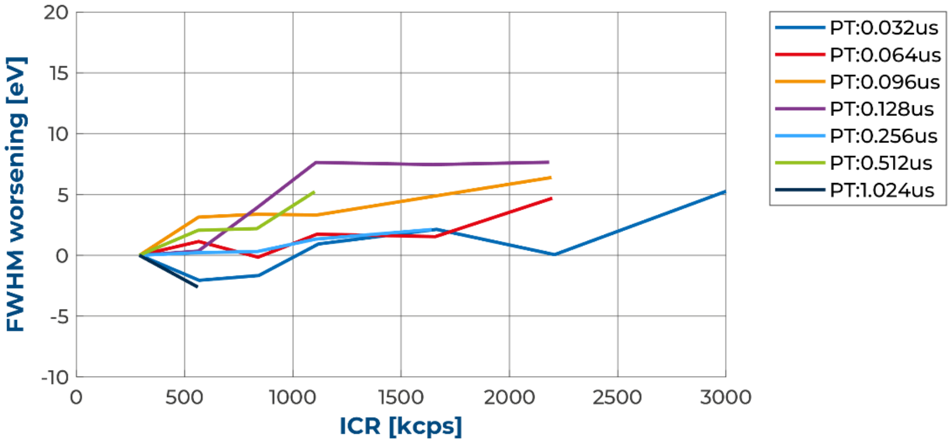
6. Performance examples

6.1 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
- **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

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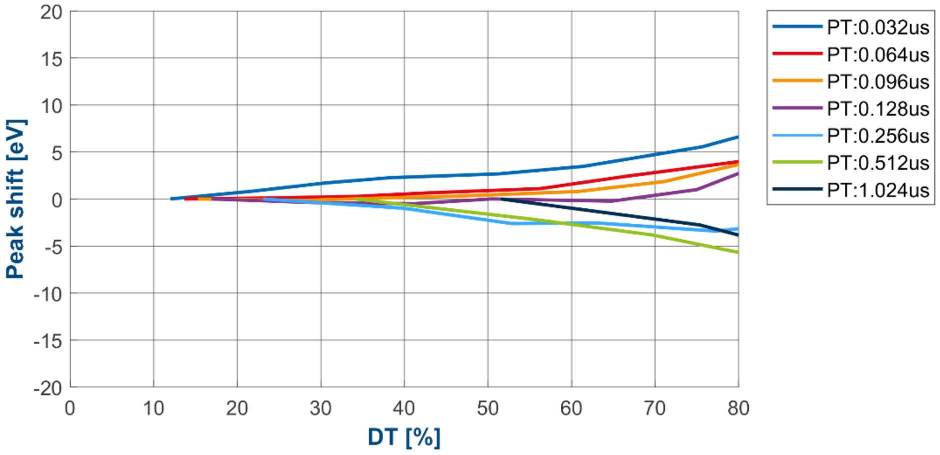
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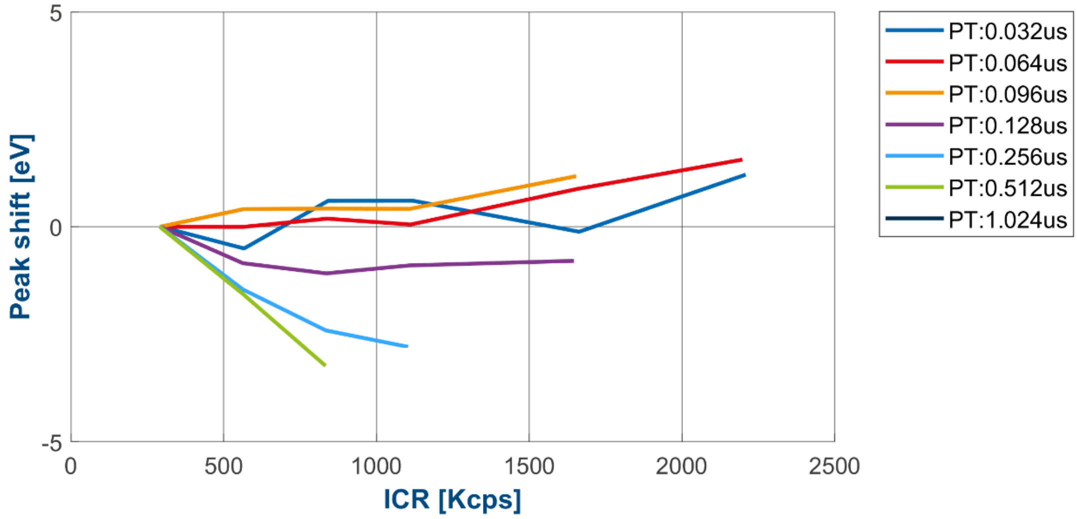
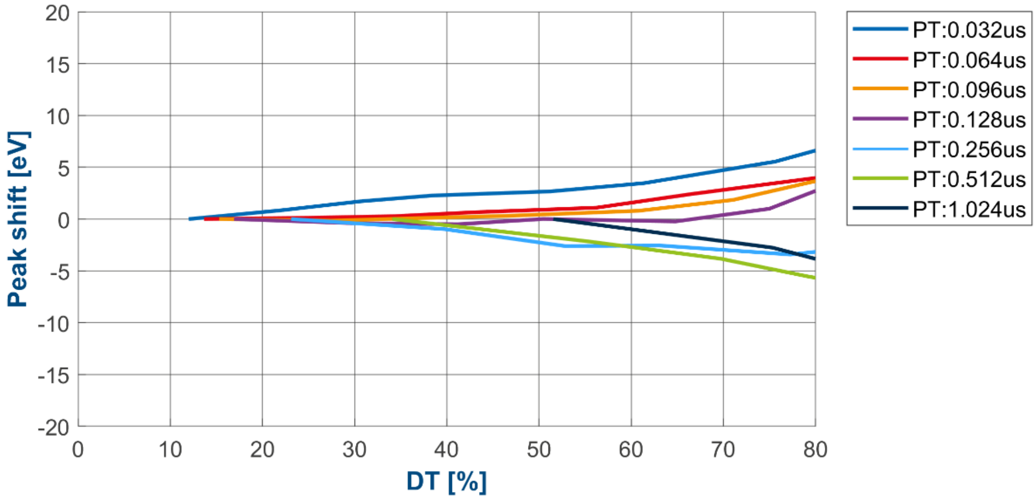
6.2 Peak Stability

Measurement setup:

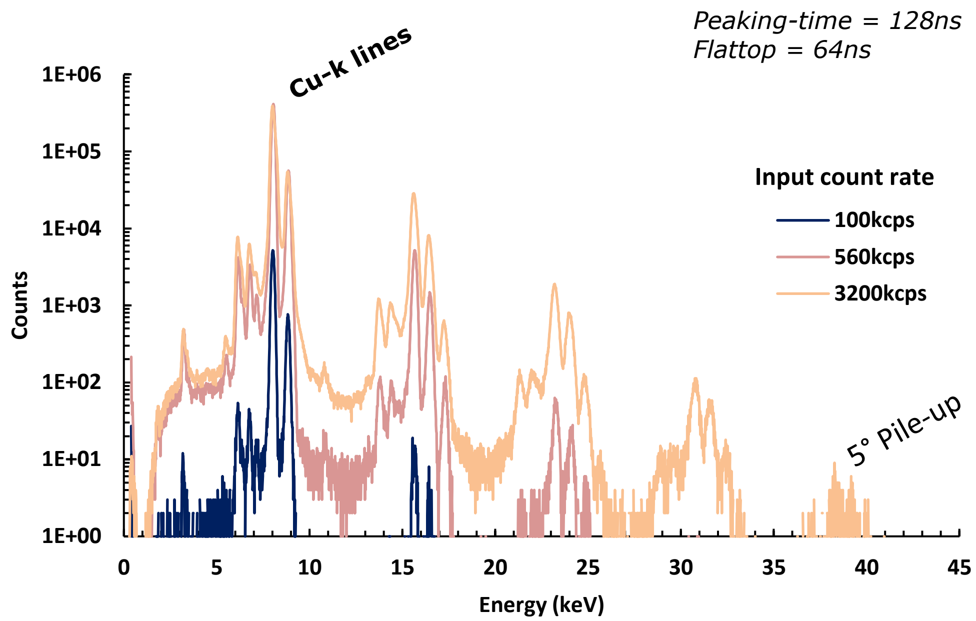
- **Firmware**: Low-Energy [LE]
- **Sources**: X-Ray tube with Mn(K) foil target (5.9 keV)
- **Detector and preamp**: 30mm² collimated
- **Preamplifier**: CUBE
- **Temperature**: -35°C
- **Flat top**: 96 ns
- **Digital gain**: 1
- **Reset recovery time**: 240ns
- **Fast filter peaking time**: 8 ns
-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




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

6.3 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 between the double peak and the single peak of the spectrum. Time resolution is dependent on the the P2P1 ration with the following relationship:

$$P2P1 = \sqrt{2} \times ICR \times \tau$$

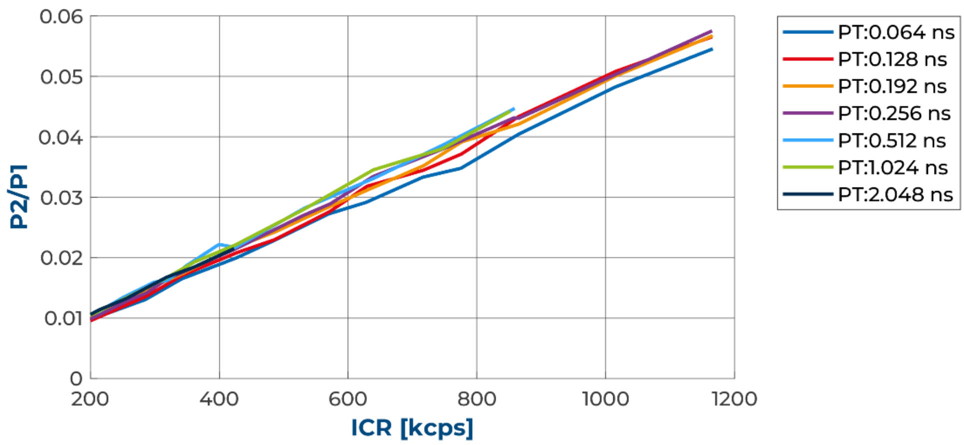
Lower P2P1 ratio means better time-resolution and better pile-up rejection performances.

The following graph shows the P2P1 ratio 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
- **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



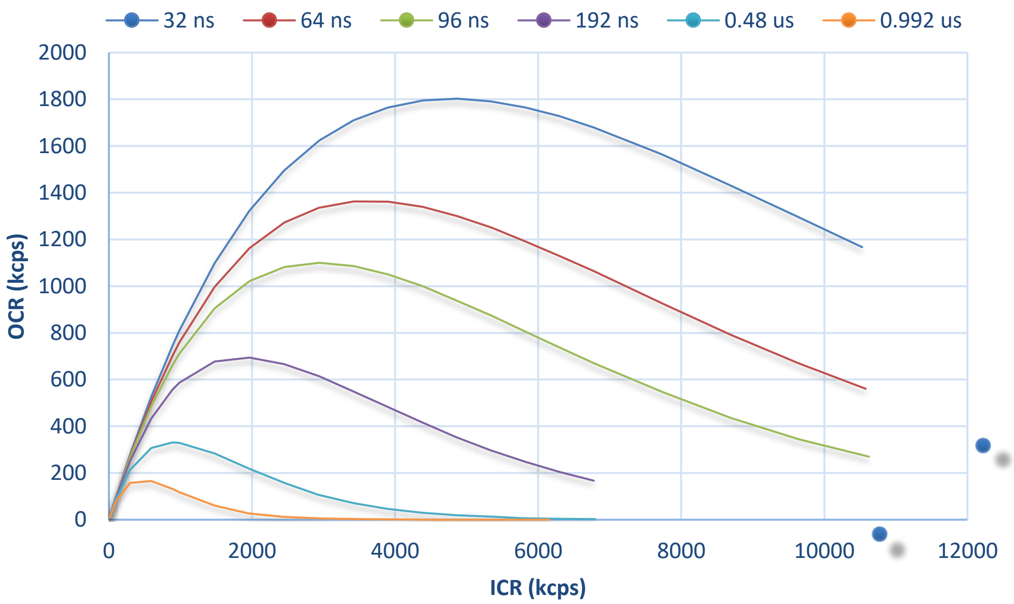
6.4 OCR vs ICR

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:

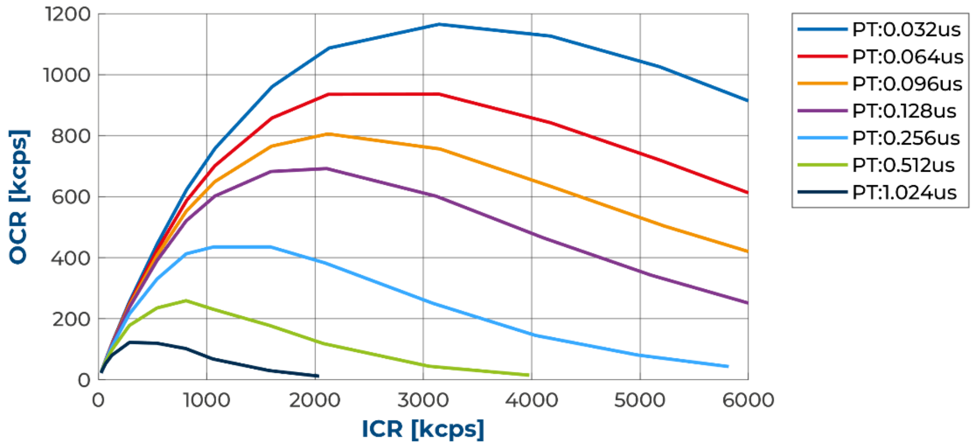
- **Flat top**: 64 ns
- **Fast filter threshold**: 100 spectrum bins
- **Digital gain**: 1
- **Reset recovery time**: 0.48 µs
- **Fast filter peaking time**: 8 ns
- **Baseline samples**: 64



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

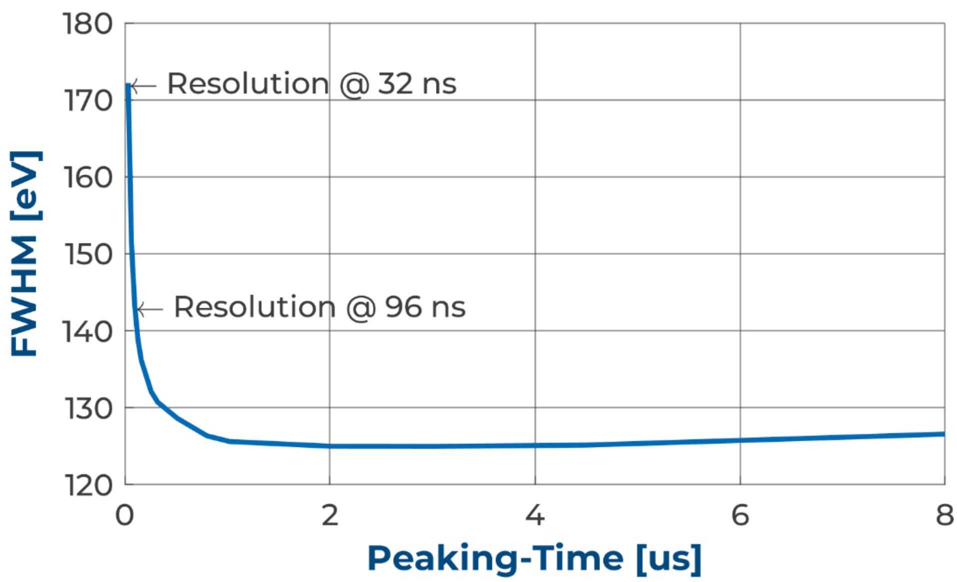


6.5 Energy resolution

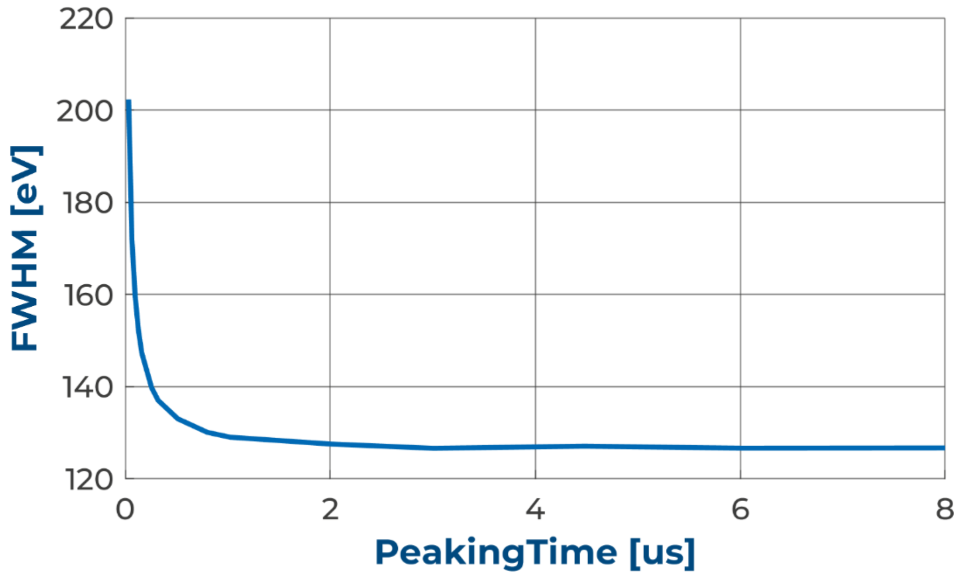
This section presents the achievable performance in terms of energy resolution. These measurements have been performed with the following setup and settings:

Measurement setup:

- **Sources**: Mn(K) source (5.9 keV)
- **Detector and preamp**: 30mm² collimated
- **Preamplifier**: CUBE, preamplifier gain 7mv/keV
- **Temperature**: -35°C
- **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

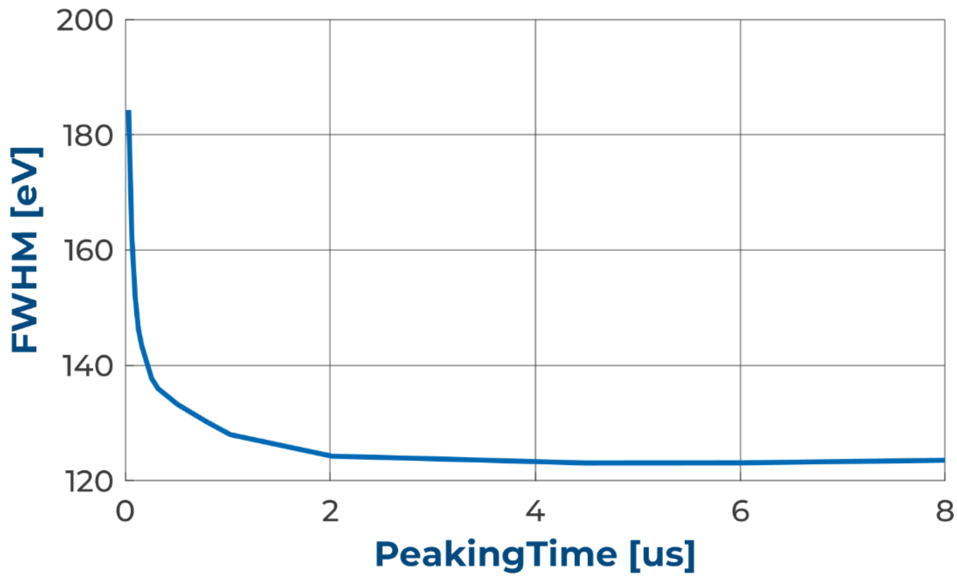


Measurement setup:
- **Source**: Fe55
- **ICR**: 100 kcps
- **Detector**: XR-100-FAST SDD
- **Preamplifier**: Cube (5mV/keV)
- **Temperature**: -38°C
- **Digital gain**: 1
- **Reset recovery time**: 2.4 us
- **Fast filter peaking time**: 32 ns
- **Fast filter flat top**: 8 ns
- **Fast filter threshold:** 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
- **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

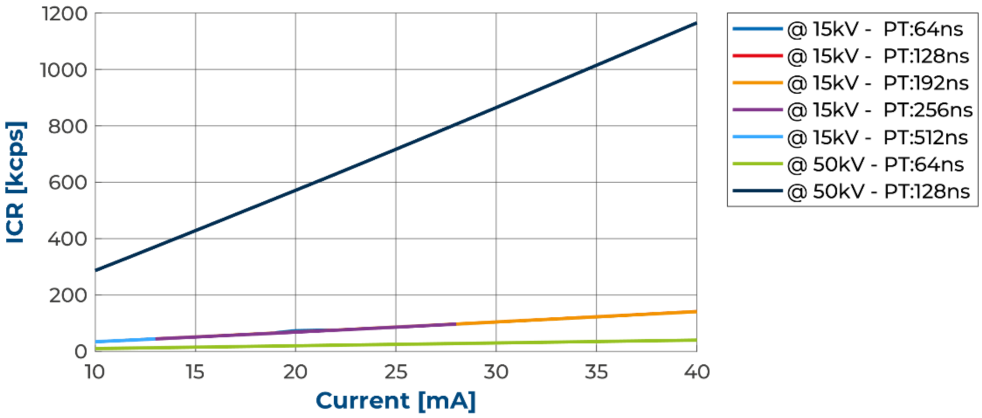


6.6 ICR Linearity

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;
- **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;

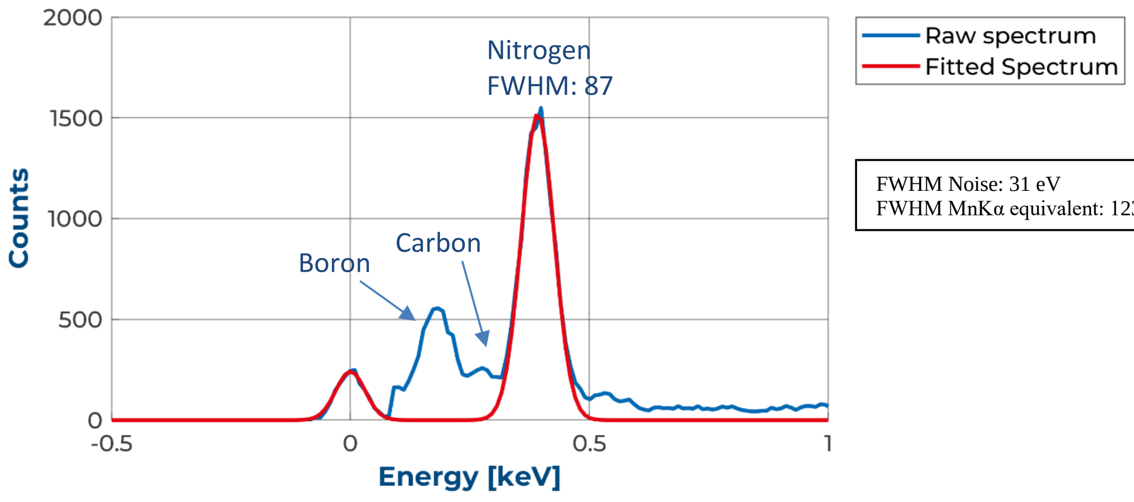


6.7 Light element efficiency

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:

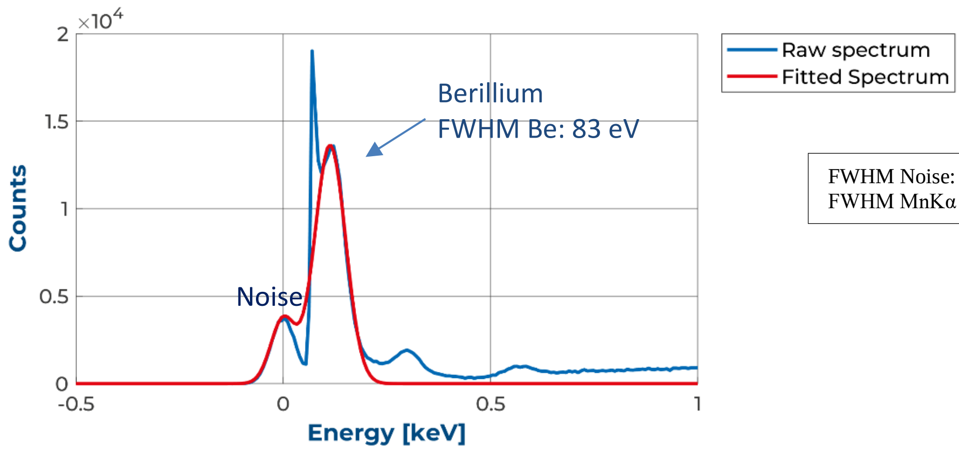
- **Sources**: Boron-Carbon-Nitrogen sample
- **Detector and preamplifier**: Bruker X-Flash
- **Temperature**: -38°C
- **Digital gain**: 1
- **Reset recovery time**: 4 us
- **Fast filter peaking time**: 120 ns
- **Fast filter flat top**: 8 ns
- **Fast filter threshold:** 100 spectrum bins
- **Max risetime**: 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
- **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

7. Application examples

7.1 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

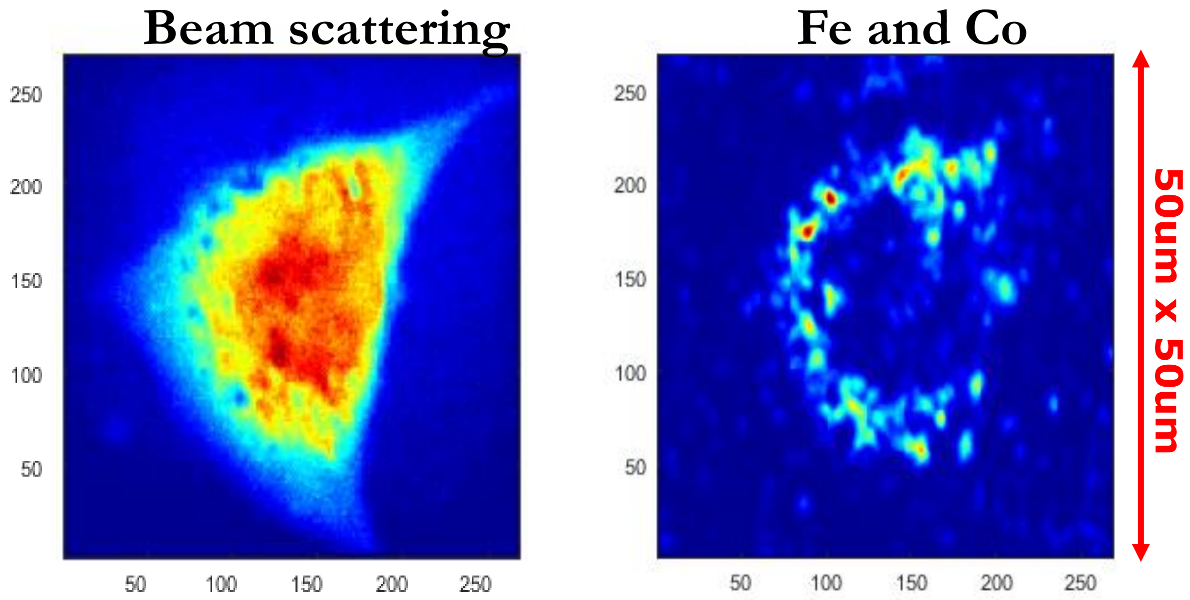


Figure 7.1: (left) Scattered beam distribution within the cell. (right) Fe and Co concentration

7.2 XAS Spectroscopy

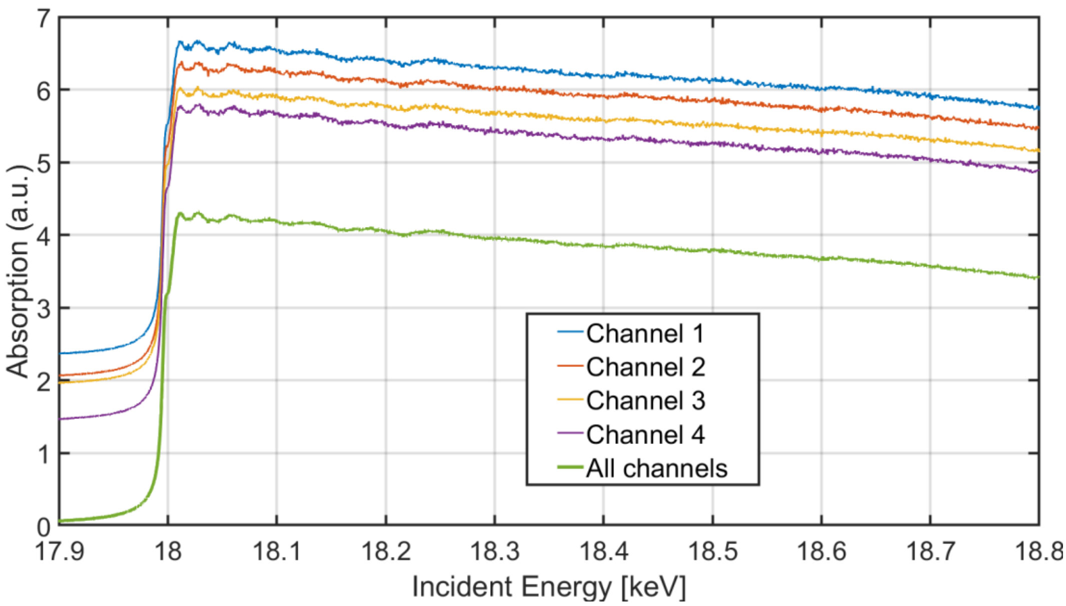
DANTE mapping mode is suitable for XAS spectroscopy measurements which is used to evaluate the x-ray absorption coefficient of a given material as a function of the incident x-ray energy.

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)



8. Revisions

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.