

Software User Manual

labZY-TDCR

Versions 7.00 to 7.49

Rev. 1a

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Overview and Installation

Software Overview

The labZY-TDCR application provides an interface to nanoTDCR devices, with the ability to set device operating parameters, verify correct device operation, acquire spectral data, and perform TDCR counting. The acquired data can be displayed and analyzed. Furthermore, acquired spectra and TDCR counting information can be stored in files for subsequent viewing and analysis.

The labZY-TDCR application is not a complete analytical software for determining the radionuclide activity. The activity calculations require a specialized software that implements the algorithms according to the TDCR counting model. While the labZY-TDCR application provides basic tools for spectral analysis, it is recommended that either open-source or commercial software packages be used for a detailed analytical assessment of the acquired spectral data.

Features

The labZY-TDCR application offers unique features that support the two distinctive functionality of the nanoTDCR hardware - spectrometry (MCA) and TDCR counting.

The MCA support includes setting of the [Spectrum Soft Size](#). All MCA spectra are recorded by the hardware at the finest channel resolution possible (the largest number of channels per spectrum). The number of channels recorded by the hardware is called the Spectrum Hard Size. The hard size spectrum is the only spectrum that is transferred from the hardware to the software. The software stores the transferred hard size spectrum in its memory and files. The labZY-TDCR application allows the hard size spectrum to be displayed and exported into a file as a Spectrum Soft Size, or a spectrum that has fewer channels than the hard size spectrum. The transformation from hard size to soft size is distortion free and does not destroy the original hard size spectrum. The labZY-TDCR application allows for instant exploration of different spectrum sizes with a single spectrum recording. This is a significant improvement in comparison to traditional MCAs, which offer hardware spectrum size selection and require spectrum recordings for each size in order to determine the optimal spectrum

size. Because the Spectrum Hard Size spectra are always stored as labZY spectrum files, it is recommended that all spectra are first stored as labZY spectrum files and then exported into soft size files. The soft size spectra can be exported into text files which can be used for processing with other spectrum analyzing applications.

The MCA part of the nanoTDCR has a built-in [Digital Pulser](#). The Digital Pulser acts like the Analog Pulser** except it is noise free and does not interfere with the detector signals. The labZY-TDCR application can turn the pulser on or off and obtain pulser peak information to estimate the intrinsic resolution of the system. The Digital Pulser can also check the base line, shaper adjustments, pulse tailing, presence of non-random signal pick-up, etc. It is not designed to be used for dead-time estimation. For more details, refer to the *labPAPER* “Digital Pulser” at www.labzy.com..

The labZY-TDCR application, in conjunction with the nanoTDCR MCA, reports the [True Incoming Counting Rate \(ICR\)](#), correcting for the pile-up losses in the fast and/or slow channels of the spectrometer. labZY’s approach has better ICR estimation than the traditional method of ICR reporting, which is based on the counting rate of the fast discriminator and is always subject to pile-up counting losses.

The labZY-TDCR application provides enhanced spectral peak information by calculating not only the full width at half maximum (FWHM) of the peaks, but by also reporting the peak [Resolution In Percentage](#). This feature is valuable for assessing the resolution of scintillation detectors, which is normally reported as a percentage.

The labZY-TDCR software has a complete set of TDCR counting control functions. It allows setting the TDCR coincidence windows and the TDCR dead time extensions. The dead time extensions can be selected as individual dead time extensions or a common dead time extension.

The software also controls the thresholds of the TDCR input discriminators. This feature provides remote settings of the thresholds without hardware intervention as in the case of mechanical trim pots.

The labZY-TDCR application delivers a full data set of the TDCR measurements. The data set includes counts, time and counting rates from a sequential TDCR counting runs. The sequential operation is fully supported by the software.

Unique feature of the labZY-TDCR software is the UTC time stamping of the TDCR and MCA measurements. The UTC time stamp is obtained from NTP time servers with typical accuracy of few milliseconds.

Installation

Supported Operating Systems:

- Windows 10
- Windows 8
- Windows 7
- Windows Vista
- Windows XP

The labZY-TDCR software can be installed either from the supplied flash drive when purchasing the device or by downloading the installation file from Download tab at <http://www.labzy.com/products/nanotdcr/>. To install the software from the flash drive, insert the flash drive into the computer's USB port. Find the labZY-TDCR directory, execute [setup_VERSION.exe](#). To install the software from www.labzy.com, first download [latest labZY-TDCR software \[zip\]](#) and unzip or open the downloaded file. The downloaded version of the software should correspond to the software version described in this manual. Execute [setup_VERSION.exe](#) and follow the instructions of the software installer as outlined below.

Step 1

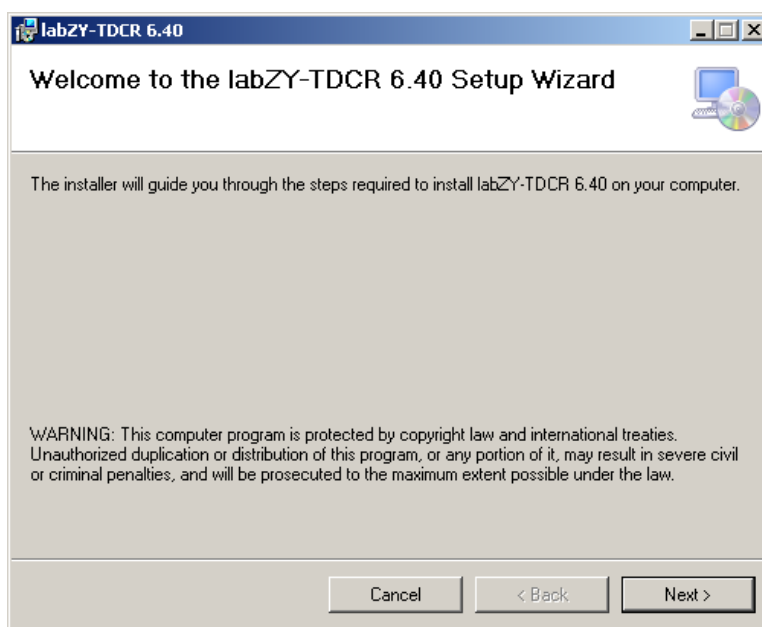


Figure 1.1. Welcome page of labZY-TDCR Setup Wizard window.

Press "Next."

Step 2

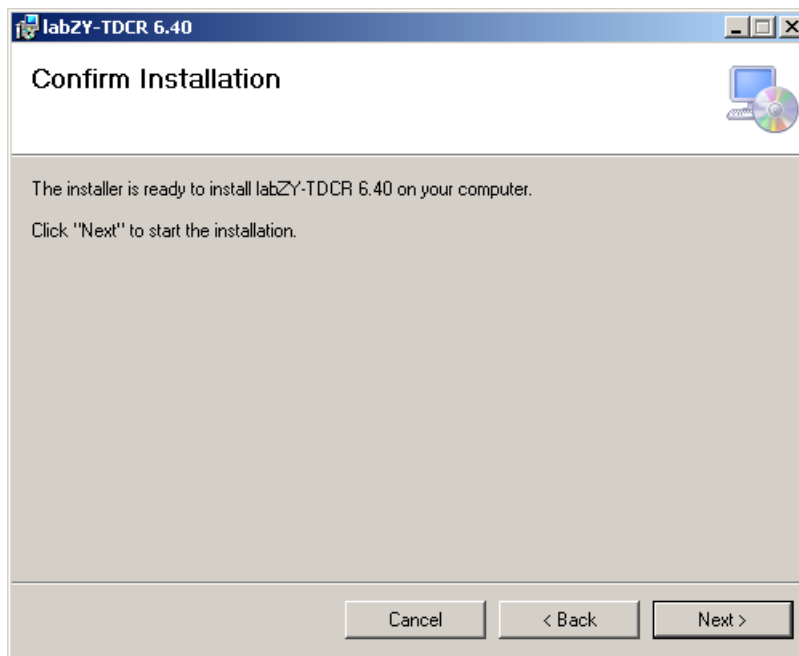


Figure 1.2 Confirm Installation page of labZY-TDCR Setup Wizard window.

Press "Next."

Step 3

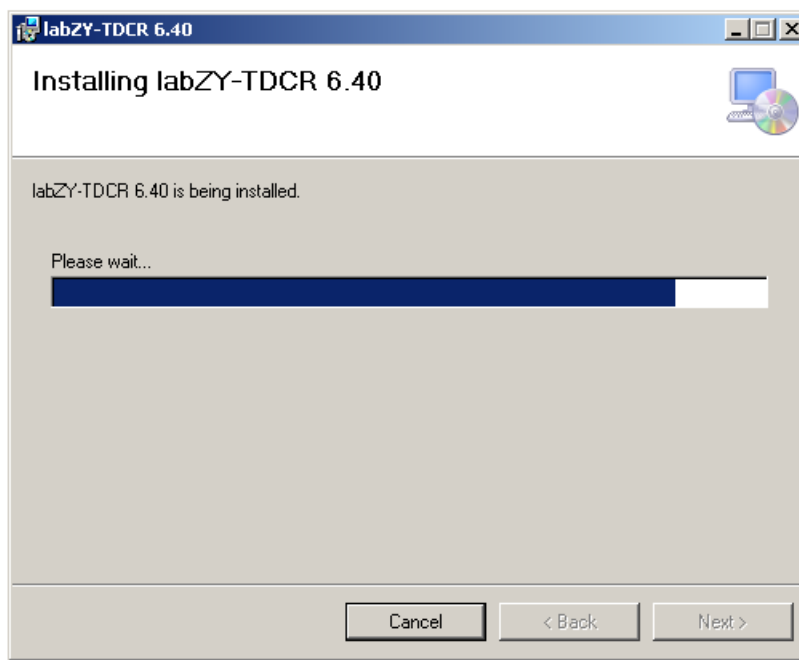


Figure 1.3. Wait for the installation to complete

Step 4

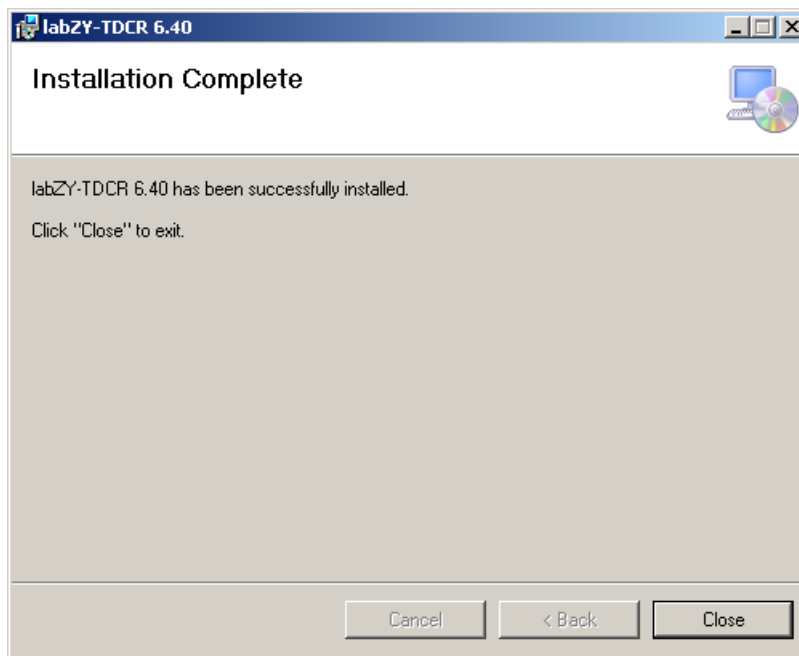


Figure 1.4. Installation Complete page of labZY-TDCR Setup Wizard window.

Press "Close."

After the installation is complete, a shortcut to labZY-TDCR application will be placed on the desktop.

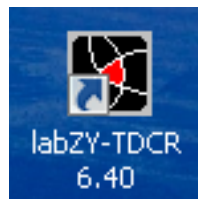


Figure 1.5. labZY-TDCR application icon.

A group called labZY will be created in "All Programs," under the start menu. The labZY folder contains shortcuts to the [labZY-TDCR software](#) and the utility to [Uninstall labZY-TDCR](#). The labZY group is shown below.

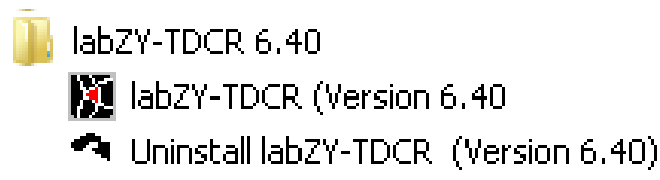


Figure 1.6. labZY group in Windows 7 and Windows XP.

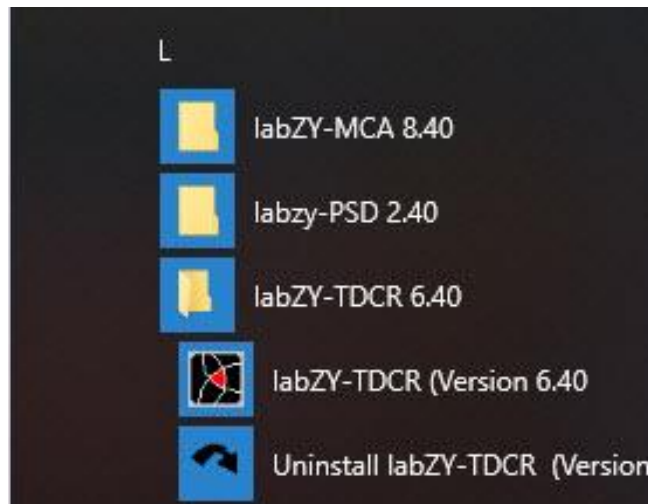


Figure 1.7. labZY group in Windows 10.

To uninstall the labZY-TDCR software, execute the [Uninstall labZY-TDCR](#) shortcut. If you need to reinstall or upgrade the labZY-TDCR software, you must first run the Uninstall labZY-TDCR utility.

Executing labZY-TDCR

The labZY-TDCR software application can be started by executing one of the shortcuts to it. The default layout of the application may differ slightly depending on the Windows version and the computer screen resolution. It is recommended that the screen resolution is greater than 1440 x 900 pixels. Depending on the Windows security settings, the following messages may appear

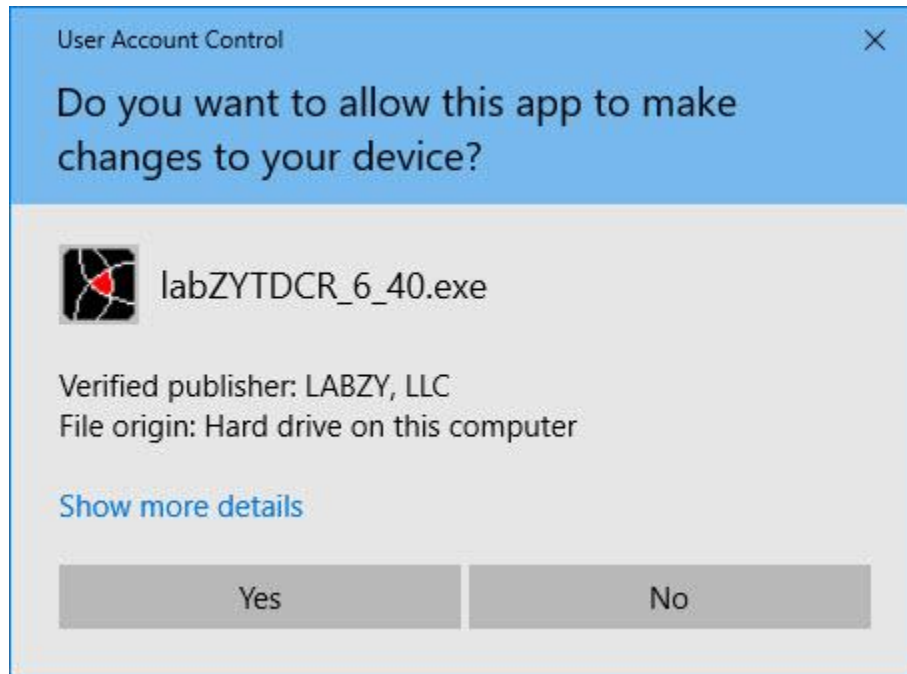


Figure 1.8. User Account Control - Verified Publisher: LABZY, LLC message.

Press "Yes."

The labZY-TDCR software will open a window displaying the default layout of the application (Fig. 1.9).

The labZY-TDCR application can be terminated by executing the [Exit](#) command of the File menu. Alternatively, the "X" button in the upper right corner may be used to terminate the application. When labZY-TDCR terminates, its current visual state is stored and will be restored at the next run. No other information is preserved upon exiting the application.

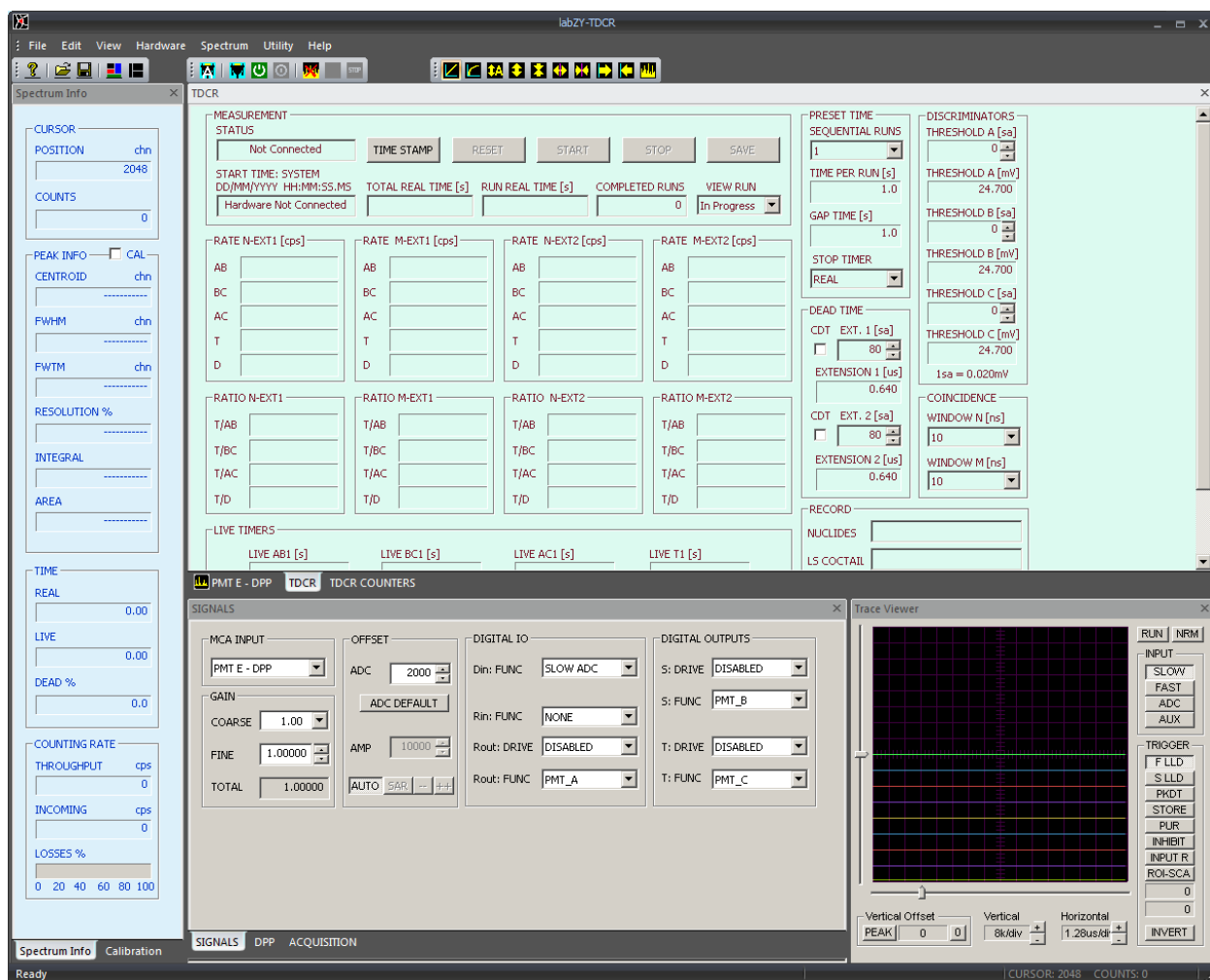


Figure 1.9. labZY-TDCR default layout.

TDCR Components

TDCR Window

The TDCR window is divided into several sections for controlling and monitoring the measurement process.

MEASUREMENT STATUS: Includes buttons for TIME STAMP, RESET, START, STOP, and SAVE. The status is currently 'In Progress - RUN 4'. It also displays the START TIME (UTC DD/MM/YYYY HH:MM:SS.MS) as 25/06/2019 21:53:55.06.

Timing and Progress: Shows TOTAL REAL TIME [s] (350.103), RUN REAL TIME [s] (50.103), and COMPLETED RUNS (3). A VIEW RUN button is available.

RATE Data (cps): Displays rates for four channels (AB, BC, AC, T, D) across four measurement types (N-EXT1, M-EXT1, N-EXT2, M-EXT2).

RATIO Data: Displays ratios (T/AB, T/BC, T/AC, T/D) for the same four measurement types.

LIVE TIMERS: Shows live times for channels AB1, BC1, AC1, T1, AB2, BC2, AC2, and T2.

PRESET TIME: Includes SEQUENTIAL RUNS (64), TIME PER RUN [s] (100.000), GAP TIME [s] (0.001), and STOP TIMER (REAL).

DISCRIMINATORS: Controls for POLARITY INPUT A, B, and C (all set to NEGATIVE), and THRESHOLD A, B, and C [mV] (all set to -19.99).

DEAD TIME: Includes MODE EXTENSION 1 (IDT selected, CDT unselected) and EXTENSION 1 [us] (1.000).

MODE EXTENSION 2: Includes MODE EXTENSION 2 (IDT selected, CDT unselected) and EXTENSION 2 [us] (1.000).

COINCIDENCE: Controls for WINDOW N [ns] (40) and WINDOW M [ns] (40).

RECORD: Includes fields for NUCLIDES (Am-241), LS COCTAIL (LS-UG), PMT HV (+812V), and OPERATOR (TD).

Figure 2.1. TDCR Window.

The TDCR window contains all nanoTDCR controls and displays the most important information obtained from the TDCR measurement. This window has groups of controls that are specific to the functionality of the nanoTDCR. The TDCR measurement can be completed and saved using controls from this window.

The MEASUREMENT group is used to control the TDCR counting. It also displays information about the progress of the measurement. The controls and the indicators in this group are the only ones needed to start, stop and reset the nanoTDCR data acquisition system.



Figure 2.2. The MEASUREMENT control group.

The TIME STAMP button invokes a Measurement Time Stamp dialog. This dialog presents options for selecting the source of the Time Stamp. The Get UTC button will obtain an UTC time stamp from internet NTP servers. Once the time stamp is obtained the labZY-TDCR software will track the and compensate for the elapsed time from the moment the time stamp is obtained to the start of the TDCR counting. The nanoTDCR will store in its memory the compensated time stamp. If more than 300s elapse from the time UTC time stamp is obtained to the start of the TDCR counting the labZY-TDCR application will issue a request for updating the time stamp from an NTP server. The dialog present options for using LOCAL time stamp which is derived from the computer clock and represents the local time. The SYSTEM time stamp is also derived from the computer clock but it represents the UTC time. It is important to understand that the computer clocks are in general inaccurate and they should not be used as critical time-related measurements. The UTC time stamps are more accurate but they require internet access with NTP ports enabled. The time stamp is displayed in the control START TIME.

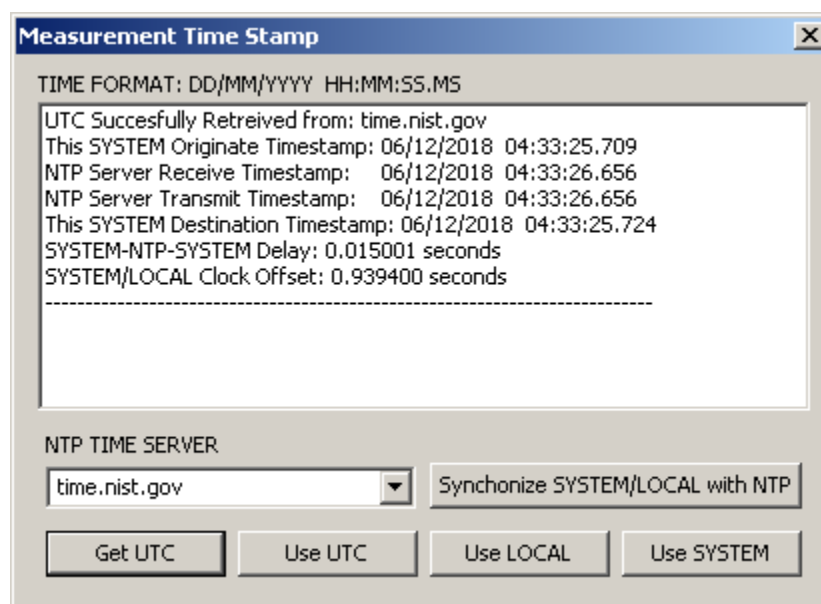


Figure 2.3. Time Stamp Dialog.

The RESET, START and STOP buttons are used to control the nanoTDCR acquisition. The operational logic of these buttons depends on the status of the nanoTDCR acquisition system which is displayed in the control STATUS.

MEASUREMENT
STATUS

Reset - Idle

TIME STAMP

RESET

START

STOP

SAVE

START TIME: UTC
DD/MM/YYYY HH:MM:SS.MS

07/12/2018 03:00:35.70

TOTAL REAL TIME [s]

0.000

RUN REAL TIME [s]

0.000

COMPLETED RUNS

0

VIEW RUN

In Progress

Figure 2.4. **Idle** Status - Ready to START TDCR counting.

MEASUREMENT
STATUS

In Progress - RUN 2

TIME STAMP

RESET

START

STOP

SAVE

START TIME: UTC
DD/MM/YYYY HH:MM:SS.MS

07/12/2018 03:00:35.70

TOTAL REAL TIME [s]

31.573

RUN REAL TIME [s]

6.573

COMPLETED RUNS

1

VIEW RUN

In Progress

Figure 2.5. **In Progress-RUN #** Status - Ready to START TDCR counting.

MEASUREMENT
STATUS

Completed - Not Saved

TIME STAMP

RESET

START

STOP

SAVE

START TIME: UTC
DD/MM/YYYY HH:MM:SS.MS

06/12/2018 04:25:16.46

TOTAL REAL TIME [s]

250.000

RUN REAL TIME [s]

25.000

COMPLETED RUNS

10

VIEW RUN

In Progress

Figure 2.6. **Completed- Not Saved** Status.

The STATUS control can display four states that depend on the state of the nanoTDCR. At the initial launch of the labZY-TDCR application the STATUS state is Not Connected as displayed in Fig. 2.2. Once a nanoTDCR device is connected the software will obtain the nanoTDCR state and will display this state even if the nanoTDCR is disconnected. The nanoTDCR acquisition system can be in the following states (Figures 2.4, 2.5, 2.6, 2.9, 2.10) - **Reset - Idle**, **In Progress - RUN #**, **Interrupted - Not Saved**, **Completed - Not Saved**, **Completed - Saved**, **Interrupted - Saved** where **Completed** indicates that a TDCR measurement has been completed as set by the PRESET TIME controls. The

Interrupted indicates that the TDCR measurement was interrupted by manually stopping the measurement or by a loss of power.

The Reset - Idle state indicates that the TDCR counters and timers are reset and ready for counting/timing. In this state the STOP button is grayed. If the RESET button is pressed the reset state will be reconfirmed and the state of the nanoTDCR acquisition system will not change. If the START button is pressed the nanoTDCR will enter acquisition state and the STATUS will change to In Progress - RUN #. While the measurement is In Progress the START button will be grayed out and the STOP button will be available to stop manually the TDCR measurement. If the measurement is stopped manually or if the nanoTDCR loses power the status will change to Interrupted - Not Saved. If the measurement completes the status will change to Completed - Not Saved and STOP button will be grayed out.

If an attempt is made to reset the TDCR counters and timers while the completed or interrupted measurement is not saved the dialog in Fig. 2.7 will be displayed. The purpose of this dialog is to prevent accidental loss of measurement data. If NO button is pressed the data of the last measurement will be lost.

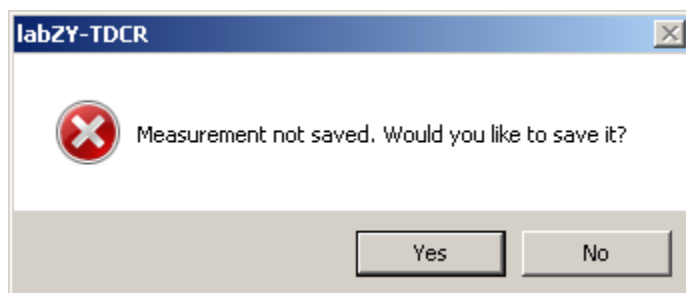
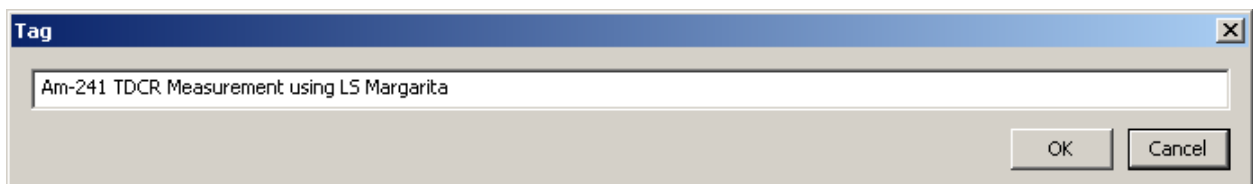
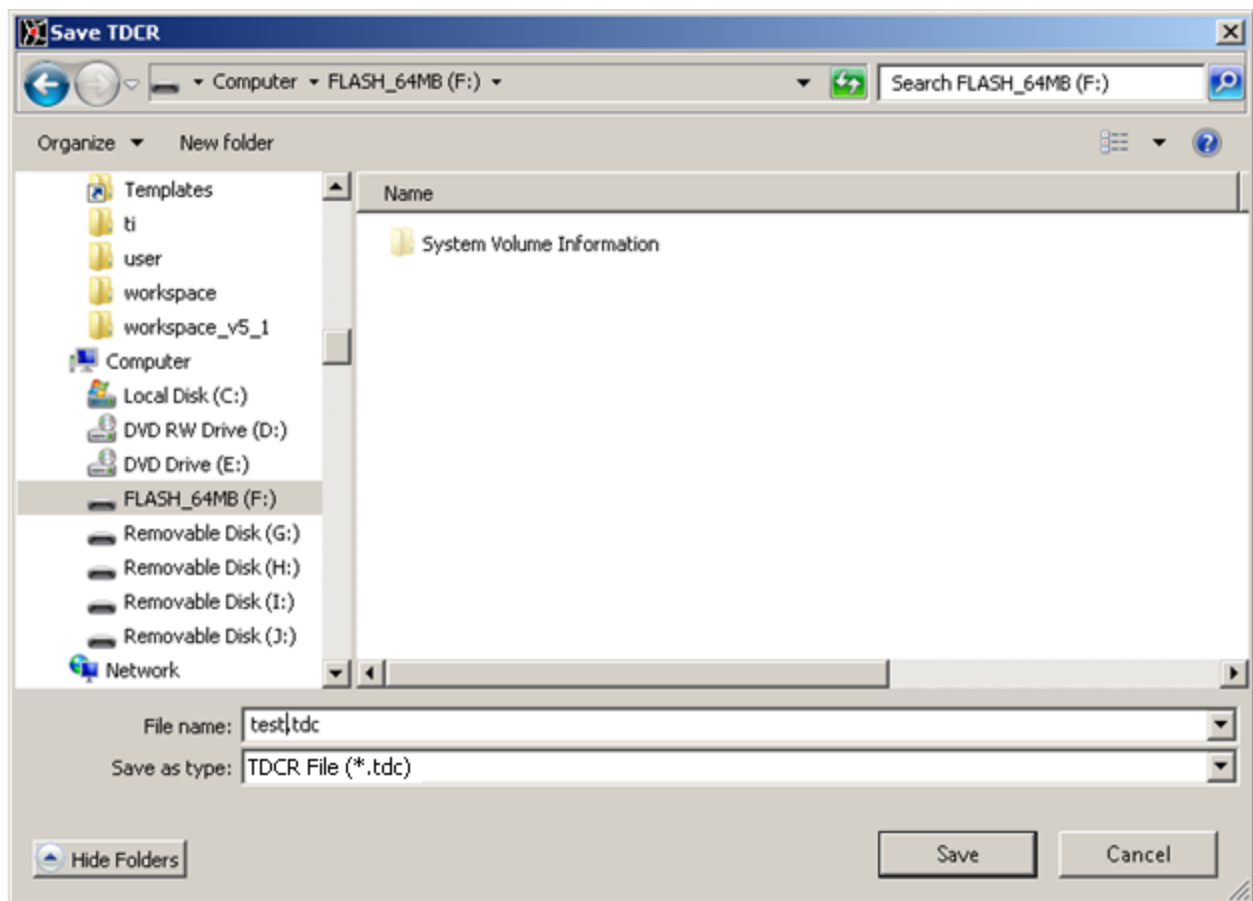


Figure 2.7. Dialog to prevent accidental loss of measurement data.

The results of TDCR measurements can be saved by pressing the SAVE button or by pressing YES button in the dialog of Fig. 2.7 which will bring a dialog to save the measurement data as shown in Fig. 2.8. The measurement data is stored in two files (*Appendix A*). Both files are text files. The TDCR file with extension **.tdc** stores all measurement parameter along with the content of all counters and timers. The **.csv** file reports only the counting rates needed for TDCR algorithms to assess the radioactivity.

Once the measurement data is saved the STATUS of the nanoTDCR will change to Completed - Saved or Interrupted - Saved (Figures 2.9 and 2.10). In this state the nanoTDCR counters and timers can be reset and a new TDCR measurement can be started. The TDCR measurement can also be saved using the menu command Save TDCR As...



test.csv	12/5/2018 9:48 PM	4 KB
test.tdc	12/5/2018 9:48 PM	30 KB

Figure 2.8. Saving the TDCR measurement.

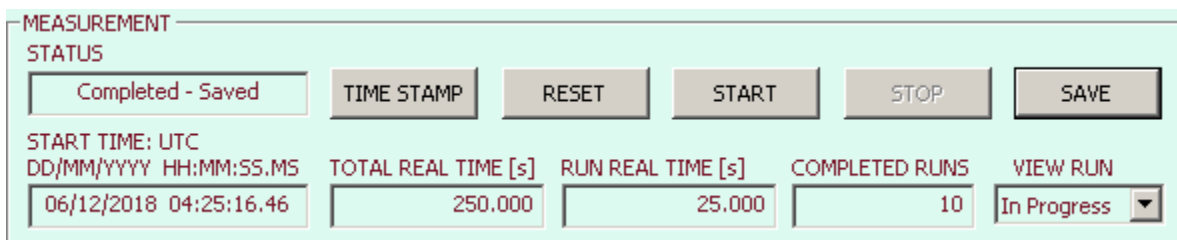


Figure 2.9. **Completed-Saved** Status.

MEASUREMENT STATUS

Interrupted - Saved

TIME STAMP RESET START STOP SAVE

START TIME: SYSTEM
DD/MM/YYYY HH:MM:SS.MS

07/12/2018 03:42:46.73

TOTAL REAL TIME [s] RUN REAL TIME [s] COMPLETED RUNS VIEW RUN

1.871 1.871 0 In Progress

Figure 2.10. Interrupted-Saved Status.

PRESET TIME

SEQUENTIAL RUNS

64

TIME PER RUN [s]

100.000

GAP TIME [s]

0.001

STOP TIMER

REAL

DEAD TIME

MODE EXTENSION 1

○ IDT ○ CDT

EXTENSION 1 [us]

1.000

MODE EXTENSION 2

○ IDT ○ CDT

EXTENSION 2 [us]

1.000

DISCRIMINATORS

POLARITY INPUT A

NEGATIVE

POLARITY INPUT B

NEGATIVE

POLARITY INPUT C

NEGATIVE

THRESHOLD A [mV]

-23.99

THRESHOLD B [mV]

-19.99

THRESHOLD C [mV]

-15.98

COINCIDENCE

WINDOW N [ns]

40

WINDOW M [ns]

40

RECORD

NUCLIDES

Am-241

LS COCTAIL

LS-UG

PMT HV

+812V

OPERATOR

TD

The DISCRIMINATORS group contains the controls of the nanoTDCR discriminator thresholds. The adjustment of these thresholds is critical for the correct TDCR counting. The nanoTDCR data sheet provides information how to adjust these thresholds properly. It is important to note that the threshold range spans from positive to negative voltage values to accommodate any offsets that may exist in the base line of the PMT signals. The threshold values can be set by typing the desired value in mV and confirming it by pressing the ENTER key or by selecting another control. Alternatively the Up and Down spin buttons can be used to adjust the threshold value.

The Input polarity can be selected individually for each counting channel of the nanoTDCR model TD9010. The Input polarity is always negative for nanoTDCR model TD9009.

The TDCR counting technique uses extended dead time to prevent false counting (e.g after-pulses) and for accurate determination of the counters live time. The controls in the group DEAD TIME are used to set the dead time extensions by directly timing the desired extension in microseconds or by using the spin buttons. The nanoTDCR has four sets of counters allowing parallel acquisition of four independent TDCR counters - combination of two

2.11. Hardware Controls.

There are two modes of operation CDT (common dead time) and IDT (individual dead time). When the CDT is selected

the TDCR counters will use the corresponding dead time extension similar to MAC3 module. If the IDT is selected each PMT channel will have its own dead/live time.

The COINCIDENCE group is used to set the width of the coincidence windows. The windows width is selected from a prefixed list of values. The selection lists for both windows is identical. This allows acquisition of CDT and IDT TDCR measurement simultaneously from the same set of PMT counts.

The PRESET TIME group contains the controls for setting the nanoTDCR timers. nanoTDCR can perform sequential repeating TDCR measurements of up to 64 RUNS. The controls allow to specify the time per run and a gap time between the runs. The minimum gap time is 100 μ s and correspond to GAP TIME setting of zero. The GAP TIME other than zero can be set in increments of 1 ms. Similarly the TIME PER RUN can be set in increments of 1 ms. The GAP TIME is always a real time. The TIME PER RUN can be either live or real depending on the STOP TIMER selection. The selected STOP TIMER determines the time of each measurement run.

The RECORD group has no association with the nanoTDCR hardware. The text fields in this group can contain any text that will be stored in the .tdc files as a measurement record.

Fig. 2.12 shows the information fields that display the main results of the TDCR counting - counting rates, ratio of counting rates and live time. The displayed results are stored in the .tdc files as a record of the TDCR measurement.

RATE N-EXT1 [cps] AB 29197.103 BC 34796.229 AC 30329.164 T 1184.072 D 91954.352	RATE M-EXT1 [cps] AB 58498.974 BC 69929.779 AC 60820.456 T 4811.321 D 179626.568	RATE N-EXT2 [cps] AB 23598.135 BC 27494.497 AC 24423.112 T 824.977 D 73865.790	RATE M-EXT2 [cps] AB 48191.073 BC 56239.376 AC 49883.216 T 3352.186 D 147609.294
RATIO N-EXT1 T/AB 0.040554 T/BC 0.034029 T/AC 0.039041 T/D 0.012877	RATIO M-EXT1 T/AB 0.082246 T/BC 0.068802 T/AC 0.079107 T/D 0.026785	RATIO N-EXT2 T/AB 0.034959 T/BC 0.030005 T/AC 0.033779 T/D 0.011169	RATIO M-EXT2 T/AB 0.069560 T/BC 0.059606 T/AC 0.067201 T/D 0.022710

LIVE TIMERS			
LIVE AB1 [s]	LIVE BC1 [s]	LIVE AC1 [s]	LIVE T1 [s]
8.285	7.690	8.154	4.558
LIVE AB2 [s]	LIVE BC2 [s]	LIVE AC2 [s]	LIVE T2 [s]
6.542	6.542	6.542	6.542

Figure 2.12. TDCR Measurement Information.

TDCR Counters Window

TDCR COUNTERS

VIEW RUN
In Progress

COUNTERS - N1	COUNTERS - M1	COUNTERS - N2	COUNTERS - M2
AB 240269	AB 482058	AB 153636	AB 314583
BC 266901	BC 537118	BC 180729	BC 369703
AC 246161	AC 495506	AC 159241	AC 325742
T 5435	T 21938	T 5435	T 21938
D 742437	D 1470806	D 482736	D 966152
ED 742461	ED 1470806	ED 482736	ED 966152

COUNTERS - PMT A	COUNTERS - PMT B	COUNTERS - PMT C	LIVE TIMERS [s]
RAW 8523044	RAW 9227335	RAW 9402614	A1 14.823
CPS 340921.760	CPS 369093.400	CPS 376104.560	B1 13.982
EX1 8523044	EX1 9227335	EX1 9402614	C1 13.773
CPS 574987.789	CPS 659943.856	CPS 682684.528	A2 16.528
EX2 8523044	EX2 9227335	EX2 9402614	B2 15.828
CPS 515673.040	CPS 582975.423	CPS 600690.858	C2 15.653

TIME CALIBRATION

SOURCE
INT 10MHz
INT REF 10MHz
EXT REF 10MHz

NONE
250000000
0
0

TDCR
TDCR COUNTERS

Figure 2.13. TDCR Counters Window.

The main function of the counters window is to display the content of the nanoTDCR counters and timers. This window has also a control for time calibration using external 10 MHz external reference clock or second built-in clock reference (currently not implemented).

Menu Components

There is only one menu command specifically related to the TDCR functionality. The command Save TDCR As... is identical to pressing the SAVE button of the TDCR Window and will result in saving **.tdc** and **.csv** files as described earlier in this section.

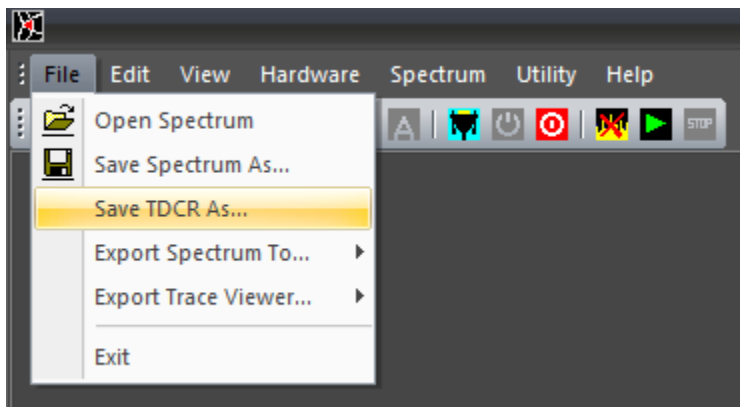


Figure 2.14. Save TDCR As... command.

MCA Components

Menu Components

File

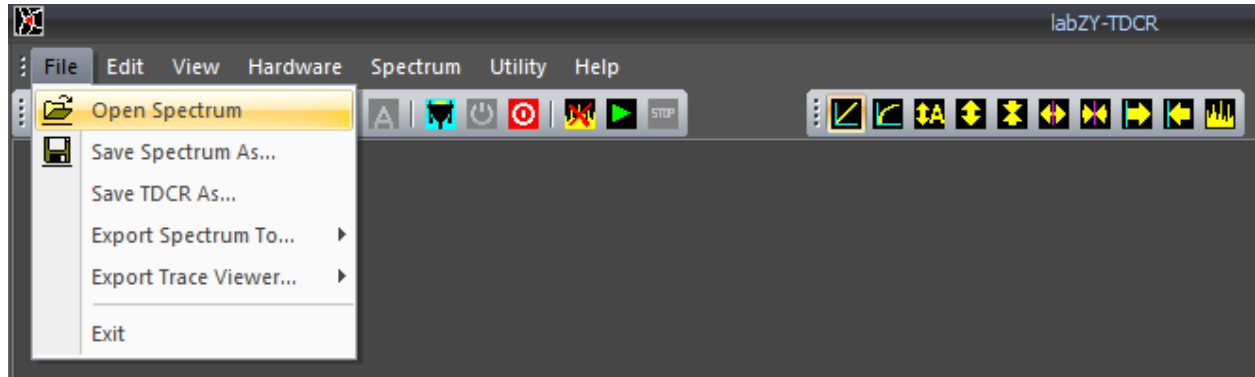


Figure 3.1.1. File menu.

The [File](#) menu can [Open Spectrum](#) files and [Save Spectrum As...](#) a labZY MCA file format, with default extension **.its**. Additionally, it can [Export Spectra](#) to other file formats. The labZY MCA file format (**.its**) and the CSV file (**.csv**) spectrum recording are described in *Appendix B*.

When saving and exporting a spectrum, a prompt is displayed to enter a [Spectrum Tag](#).

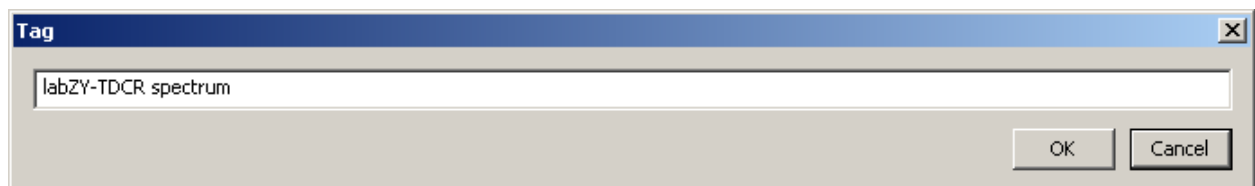


Figure 3.1.2. Spectrum Tag.

This tag can be a brief description of the spectrum or any other information that can be used as a future reference when the file is opened and/or processed. The tag limit is 80 characters. The tag is always saved in labZY formatted files and CSV exported files. Using commas in the CSV file tag will cause the comma-separated text fields to be treated separately by software applications such as Microsoft Excel.

IMPORTANT: Prior to saving a spectrum seen in the spectrum buffer, spectrum acquisition must be stopped for at least 3 seconds. This is because the spectrum buffer represents an active hardware spectrum acquisition.

Saving spectra using the labZY file format also saves all of the hardware settings including the TDCR counter settings. In addition all volatile data such as device temperature is recorded at the time of saving. **To save the hardware settings**, it is important that the [Buffer](#) tab of the [Spectrum Window](#) is selected and the labZY-TDCR application is connected to a nanoTDCR device. The ROI and calibration data are also stored in labZY spectrum files.

The [Open Spectrum](#) command can only open spectra saved in a labZY MCA file format with extension **.Its**. When a spectrum is opened, it is loaded into a separate memory displayed under the File tab of the [Spectrum Window](#). When the file tab is selected, the title bar of the Spectrum Window displays the file path and file tag of the spectrum being viewed.

Furthermore, when a spectrum is opened, the hardware settings are recalled and stored in a virtual hardware. It is possible to transfer the virtual hardware settings to the physical hardware using the [Copy Registers → File to Buffer](#) command of the [Hardware](#) menu, which will load the previously stored hardware configuration into the physical hardware. While the File tab is selected for a loaded spectrum, all hardware-related menu commands, the hardware-related windows and the toolbar buttons are disabled, as they are separate controls from the Buffer hardware controls. These separate controls relate only to the virtual hardware and not to the physical hardware (nanoTDCR) connected to the labZY-TDCR application.

The calibration and ROI data are also recalled when a spectrum is opened. These data are also stored separately in memory associated with the File tab of the [Spectrum Window](#). The calibration and ROI data can be exchanged between File and Buffer data storages using the appropriate [Copy Calibration](#) and [Copy ROI](#) commands in the Spectrum menu.

Additionally, the spectrum loaded by the [Open Spectrum](#) command and displayed in the File tab can be further analyzed by marking ROIs and/or by using the functions available in the [Calibration Window](#). Spectrum information of the File tab is separate from the spectrum information of the Buffer tab. The loaded spectrum in the File tab along with any calibration and/or ROI changes can be saved or exported under a different name.

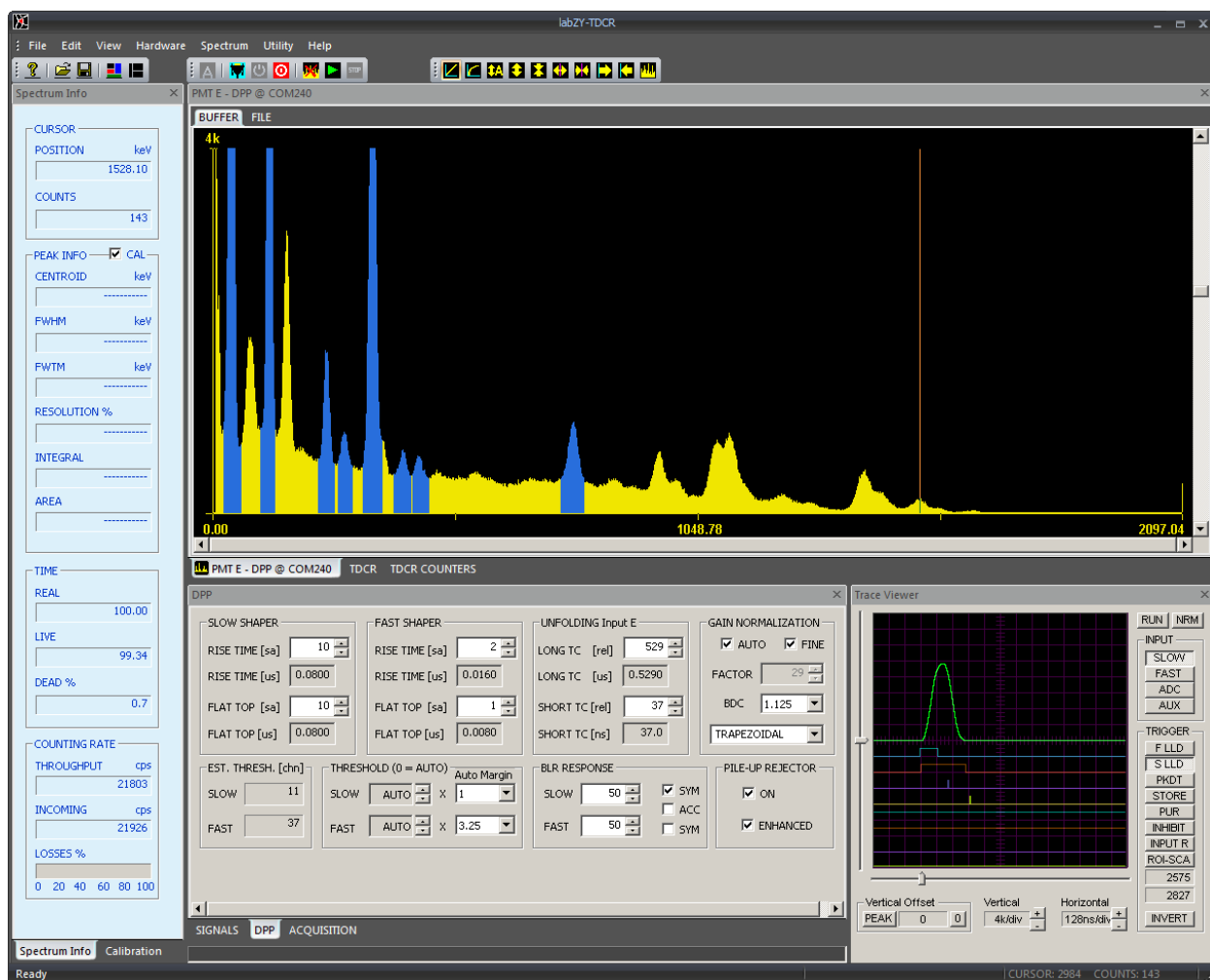


Figure 3.1.3. labZY-TDCR sample spectrum (Eu-152, LaBr detector, Input E) in default layout.

The [Export Spectrum To....](#) command has a selection of different file formats. The spectrum can be exported either as a [Hard Size Spectrum](#) or as a Spectrum with the currently selected [Soft Size](#). These software releases allow the spectra to be exported in a CSV file format (**.csv**). Note that exported spectra not in **.csv** format may not be opened by the labZY-TDCR application.

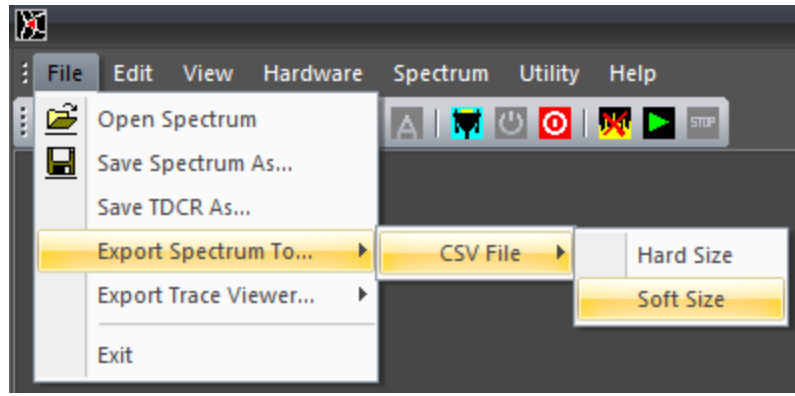


Figure 3.1.4. File menu → Export Spectrum To... → CSV File options.

The [Export Trace Viewer....](#) command is used to export the numerical data corresponding to the currently displayed waveforms by the [Trace Viewer](#). The [RAW Traces](#) are the digital signal data as transferred from the hardware. The digital signal in the [Normalized Traces](#) has been amplitude-corrected for the digital shaper gain. It is recommended to export traces as Normalized Traces. The logic signals are exported as a sequence of ones and zeros. The trace data is in CSV or TXT file formats suitable to be opened by Microsoft Excel or other spreadsheet applications.

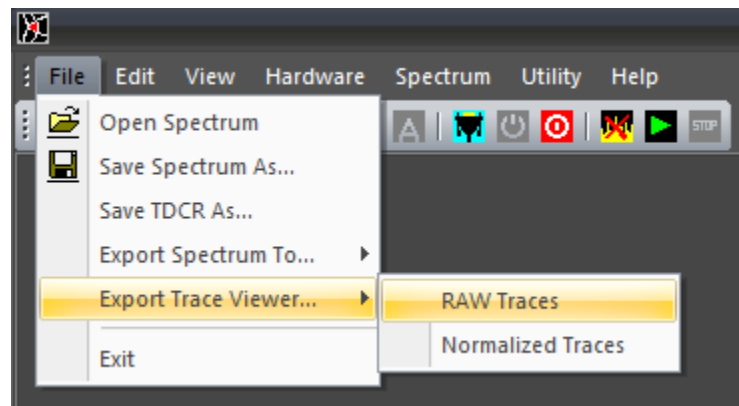


Figure 3.1.5. File menu → Export Trace Viewer... options.

Edit

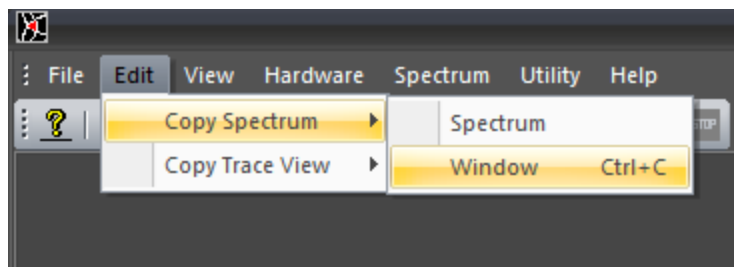
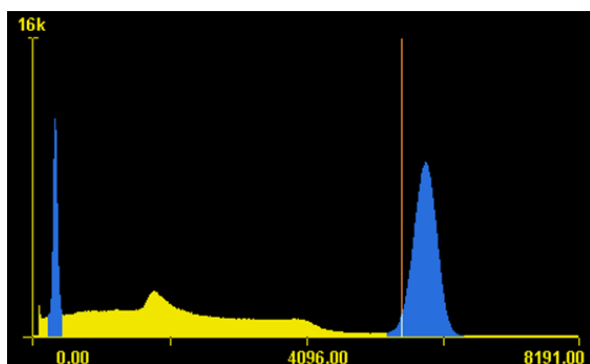
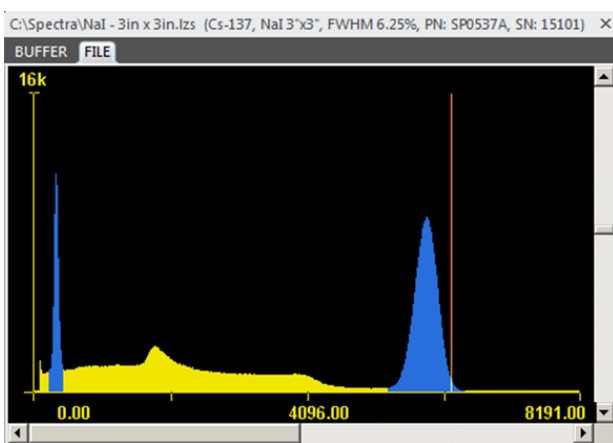


Figure 3.1.6. Edit menu → Copy Spectrum options.

The **Edit** menu has commands that allow copying of the docking windows' visual content to the clipboard. Note that the copied images are exact copies of the windows and their content as shown on the display. If other windows block the visual content of the windows being copied, the blocking overlay will be captured upon executing the copy commands. The **Copy Spectrum** command has two selectable options in a submenu. The **Spectrum** option will copy only the spectrum area of the Spectrum Window. The **Window** option will capture the entire Spectrum Window including its border and caption, and can be executed using the keyboard shortcut **Ctrl+C**.



a)



b)

Figure 3.1.7. Clipboard Images: a) **Copy Spectrum → Spectrum**;
b) **Copy Spectrum → Window (Ctrl+C)**.

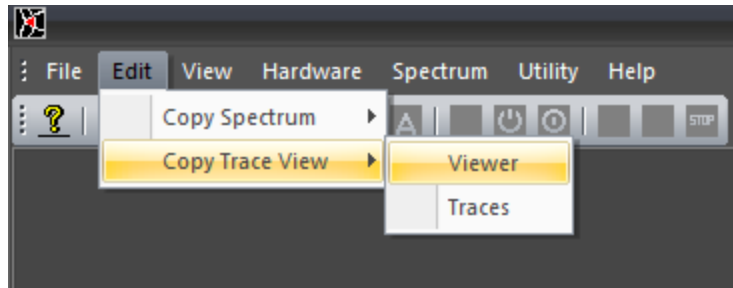
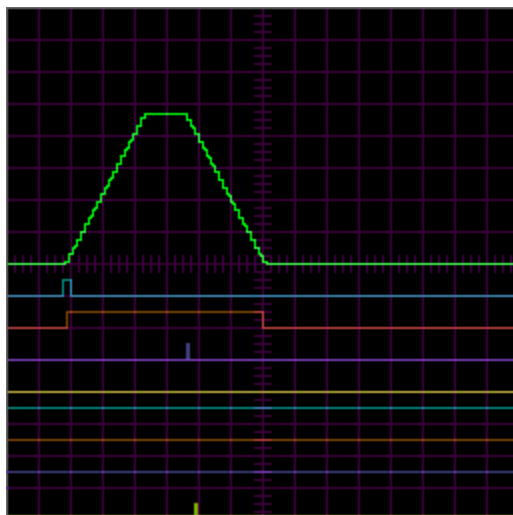
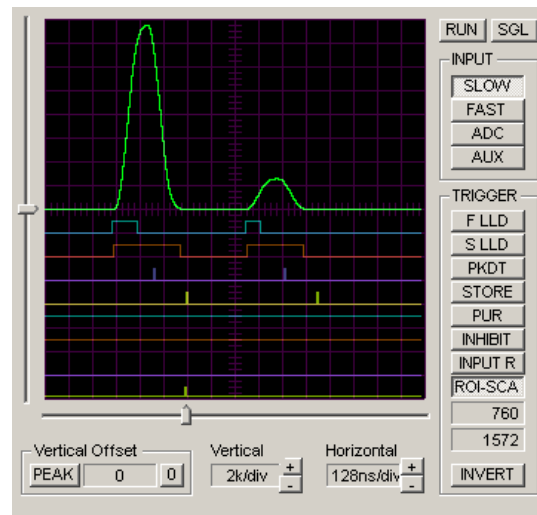


Figure 3.1.8. Edit menu → Copy Trace View options.

The [Copy Trace View](#) option will copy the visual content of the Trace Viewer to the clipboard. This command has two options. The [Traces](#) option will copy only the trace area of the Trace Viewer. The [Viewer](#) option will capture the entire Trace Viewer window including the window border and all Trace Viewer controls as displayed on the screen.



a)



b)

Figure 3.1.9. Clipboard Images: a) [Copy Trace View](#) → [Traces](#); b) [Copy Trace View](#) → [Viewer](#).

View

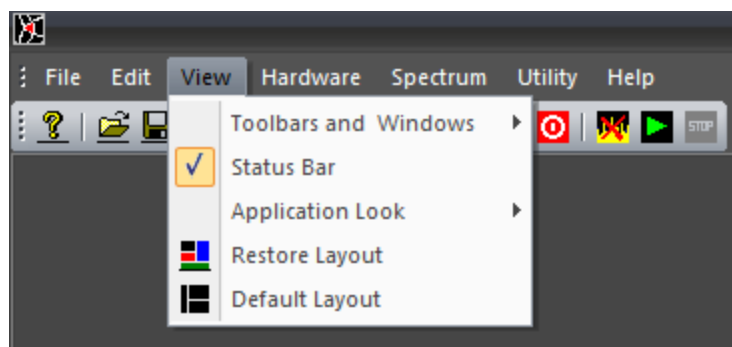


Figure 3.1.10. View menu.

The [View](#) menu controls the appearance of the application. The [Toolbars and Windows](#) command offers a submenu to turn the [Toolbars](#) (Standard, Hardware Control, View Control), and the [Docking Windows](#) ON or OFF. A check mark next to a window or a toolbar indicates that the corresponding window or toolbar is turned ON. By selecting the [Status Bar](#) command, the [Status Bar](#) can be turned ON or OFF.

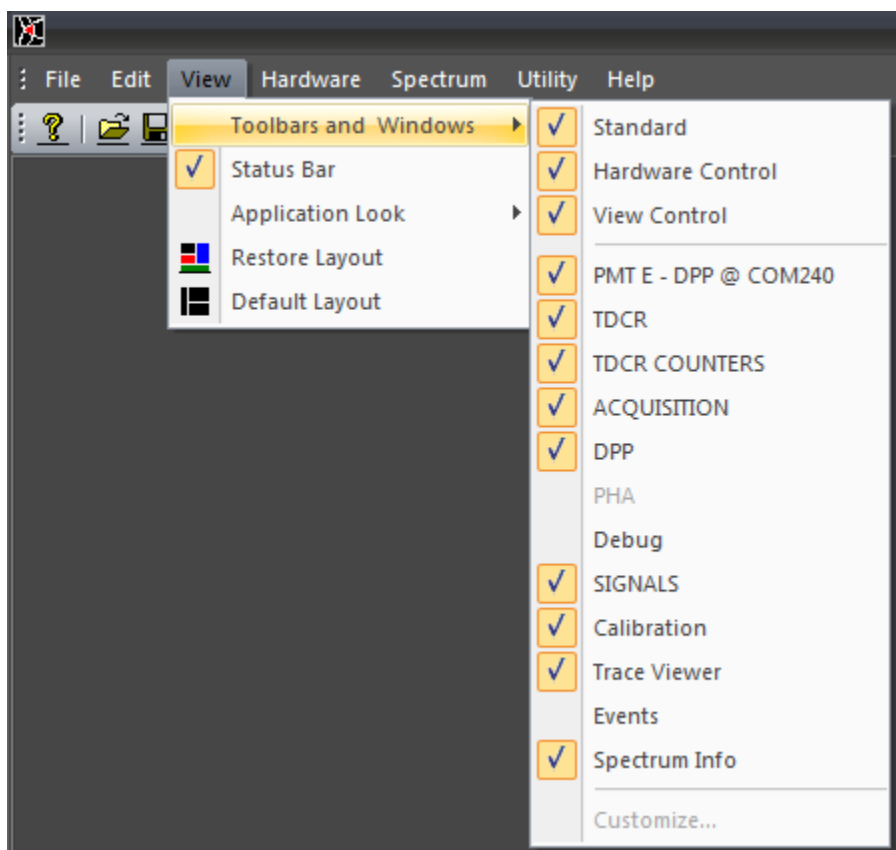


Figure 3.1.11. View menu → Toolbars and Windows options.

The [Application Look](#) command has submenus with different application styles. Some Windows versions may not support or correctly display some of the styles. The default style is Black Style.

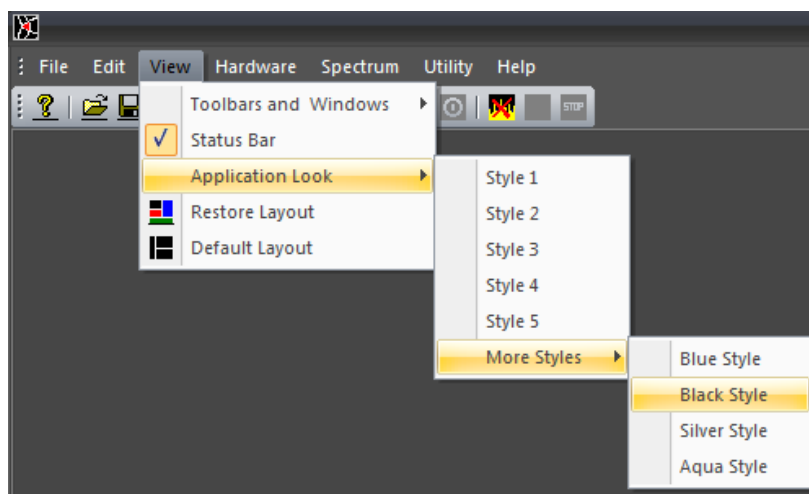


Figure 3.1.12. View menu → Application Look.

[Restore Layout](#) restores the size, position, and other view attributes (excluding the [Application Look](#)) from when the application was last opened. This command is useful if the docking windows become hidden or scrambled. Note that at exit, labZY-TDCR stores the current appearance of the application, which is automatically reloaded at the next start. This reloaded appearance will be restored if the [Restore Layout](#) command is executed.

[Default Layout](#) restores the size, position, and other view attributes to the default state at the time of software installation.

Hardware

The [Hardware](#) menu has various controls related to the labZY hardware.

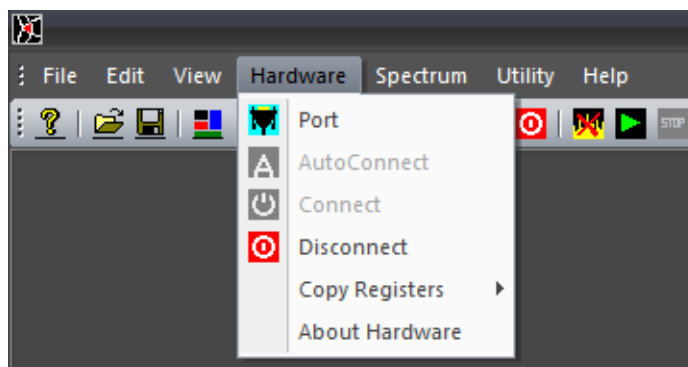


Figure 3.1.13. Hardware menu.

The [Port](#) command allows the user to choose the communication port of the connected hardware. This command may also be used to identify the port of a specific connected nanoTDCR. The port identification can only be performed for USB ports. To identify the port, start the labZY-TDCR application and disconnect the nanoTDCR of interest from the computer. Execute the [Port](#) command from the menu. A port dialog will open.

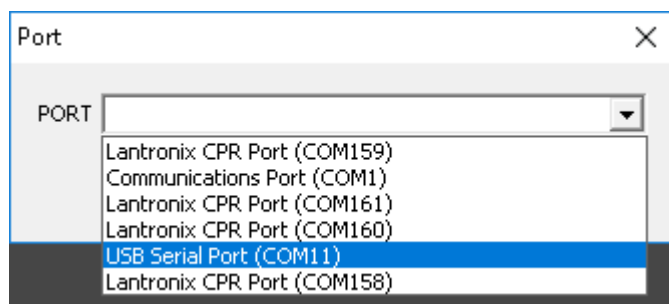


Figure 3.1.14. Available ports (Hardware > Port).

Take note of the drop-down list of available ports. Close the port selection. Connect the hardware to an available USB port. Wait until the USB driver installs. Re-open the dropdown list of ports. The new USB port should appear in the drop-down list when compared with the port list before the hardware connection. If the port list does not change, then either the USB driver was not installed correctly, or the hardware failed to connect to the USB port. If the port of the nanoTDCR is identified, select the relevant port and close the dialog by pressing "OK."

Once the port has been identified and selected, the labZY-TDCR application can establish connection to the hardware by executing the [Connect](#) command. The [Connect](#) command is disabled during an active connection.

The [AutoConnect](#) command does not require port selection and will automatically search for nanoTDCR and connect to them. **It is strongly recommended that the [AutoConnect](#) command is used to connect to nanoTDCR.**

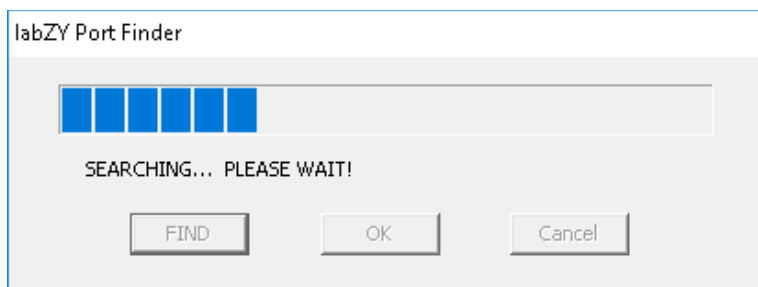


Figure 3.1.15. labZY Port Finder window during a search.

If more than one device is found, the [AutoConnect](#) dialog will present a drop list to choose a port. The found devices in the drop list will be identified by their serial number and the port they are connected to. Select the port of the device of interest and press the “OK” button.

If the [AutoConnect](#) fails to find a device, it may be executed a couple more times. If no ports are found after a few attempts, a hardware connection and/or driver installation troubleshooting must be performed.

The [Disconnect](#) command will disconnect the labZY-TDCR application from the hardware. The Disconnect command is disabled if no hardware is connected.

The [Copy Registers](#) command is used to transfer hardware settings from spectrum [Buffer](#) to [File](#) and vice versa. **It is strongly recommended that the users exercise extreme caution as the action caused by this command is not reversible.** It is recommended to save the hardware settings before executing the [Copy Registers](#) command. To save the hardware settings, use [Save Spectrum As...](#) to store a [Buffer](#) spectrum of a connected nanoTDCR. The spectrum can be blank; the labZY spectrum file record always includes the hardware settings.

Every saved spectrum has hardware settings stored in it. These settings can be transferred to the hardware by executing the [Copy Registers](#) → [File to Buffer](#) command. To transfer settings to a nanoTDCR, first establish a connection between the device and the labZY-TDCR software. Next, open a file containing the hardware settings to be uploaded to the hardware. Execute the [Copy Registers](#) → [File to Buffer](#) command, accepting the displayed warning. This should complete the transfer. Note that only hardware-related settings can be transferred. For example, the Soft Size setting will not be transferred as it is a pure software feature.

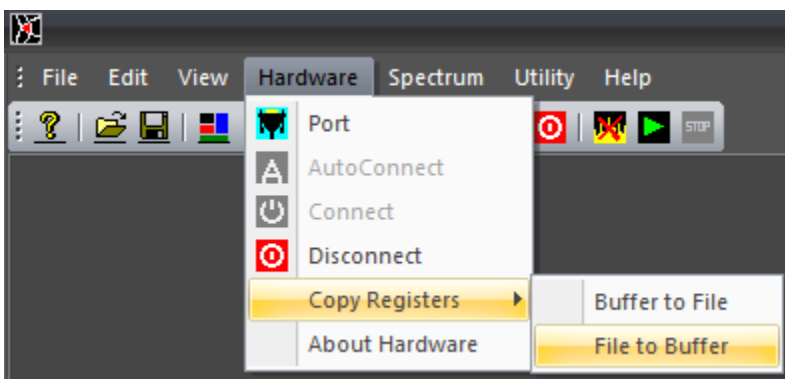


Figure 3.1.16. Hardware menu → Copy Registers options.

The [Copy Registers → Buffer to File](#) command can be used for a temporary storage of hardware settings while the labZY-TDCR application is running. If needed, these temporarily stored settings can be restored to the hardware using the [Copy Registers → File to Buffer](#) command. Although it is possible to modify the hardware settings of saved spectra, such practice should be avoided as the original hardware settings saved with the corresponding spectrum will be permanently lost.

When a nanoTDCR is connected, the [About Hardware](#) option will be enabled. This command opens an information window displaying hardware specific information such as the serial number, the expected time constant of the input signals, the version of the FPGA design, and other hardware-related details.

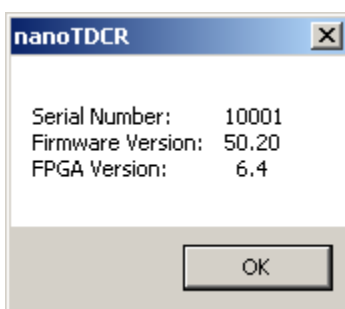


Figure 3.1.17. About hardware

Spectrum

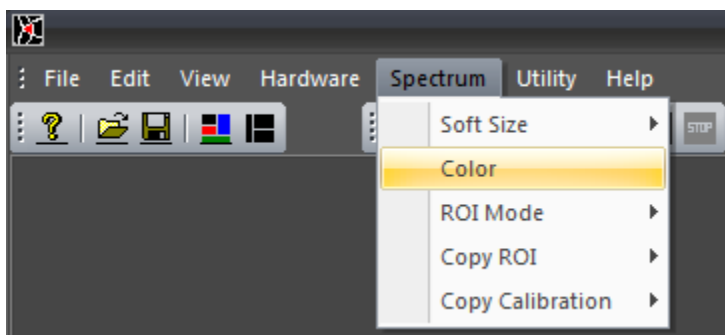


Figure 3.1.18. Spectrum menu.

The [Spectrum](#) menu controls various aspects associated with the acquired spectra or the spectra opened from files. The [Soft Size](#) command opens a submenu with choices of the spectrum soft size. A check mark next to a soft size indicates the current selection. The soft size is controlled independently for the [Buffer](#) and the [File](#) spectra.

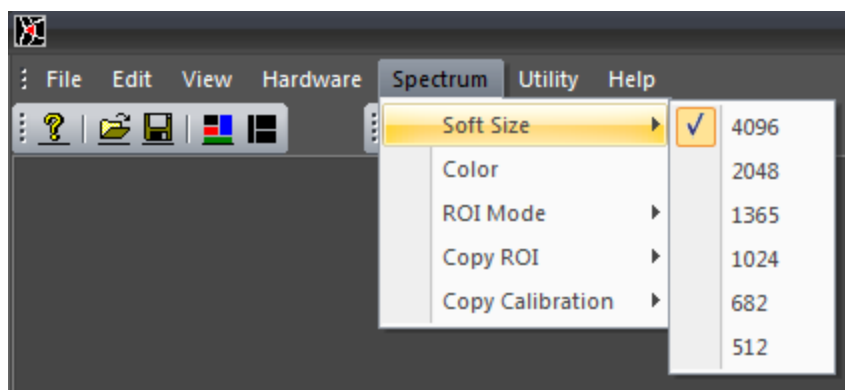


Figure 3.1.19. Spectrum menu → Soft Size options.

The [Soft Size](#) selection applies to the spectrum visible in the [Spectrum Window](#). The spectrum [Buffer](#) soft size can also be selected from the [Acquisition Window](#). The selection of the [Soft Size](#) from the [Acquisition Window](#) and from the [Spectrum](#) menu is cross-correlated and will display the corresponding soft size for both the [Spectrum Window](#) and [Buffer](#) spectra, but will only actively update the [Buffer](#) spectrum. When switching between different soft sizes, the ROI and the calibration coefficients are also adjusted accordingly. However, the data used for calculating the calibration parameters may not propagate correctly. This may lead to corrupted calibration if the calibration is enabled/disabled or recalculated without updating the calibration points for a specific soft size.

The [Color](#) command invokes a dialog to adjust the colors used to display the spectrum and associated features. Specific colors can be set by pressing the corresponding button in the [Adjust Colors](#) dialog. To set the default colors, press the Default button. The “OK” button will confirm the color selection. The “Cancel” button will disregard any color changes. Color settings are stored at the termination of the labZY-TDCR application and will be restored at the consecutive execution of the software.

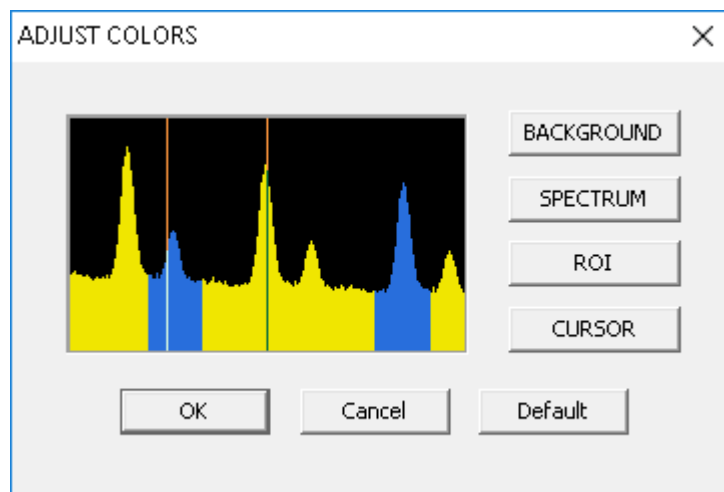


Figure 3.1.20. Adjust Colors Dialog.

The [ROI Mode](#) command determines how the ROI (Region of Interest) is marked. To understand how to mark an ROI, refer to [Mouse and Keyboard Functions](#). There is no limit on the number of marked ROI, besides the limit of available channels in the full spectrum.

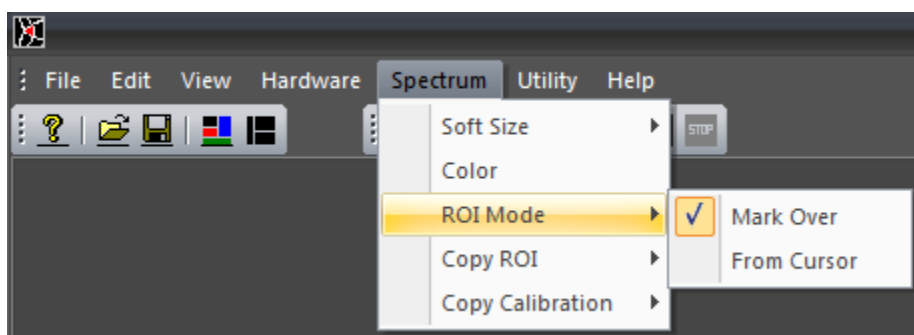


Figure 3.1.21. Spectrum menu → ROI Mode options.

The [Mark Over](#) mode is the default mode. While marking an ROI, any channel the cursor is moved over, will be marked as an ROI. All previous ROI that the cursor touches or passes over will be connected. Thus, in this mode an ROI will be marked between the extremes of the cursor movement, plus any ROIs touched by the cursor at its extreme positions.

The ROI mode [From Cursor](#) will mark the ROIs from the current cursor position either to the left-end cursor position or to the right-end cursor position. In this mode, only one previous ROI can be attached to the newly created ROI.

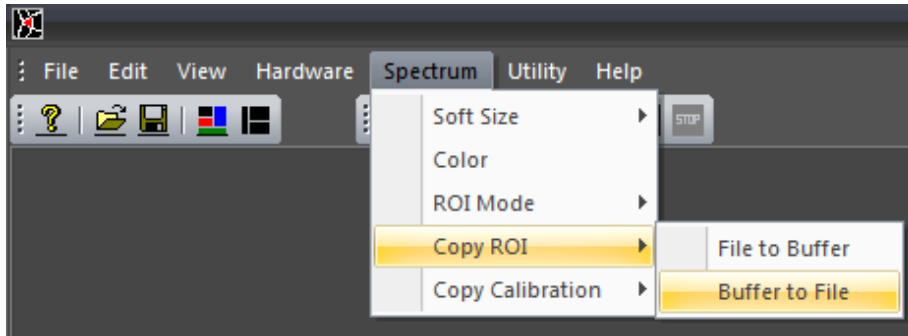


Figure 3.1.22. Spectrum menu → Copy ROI options.

The ROIs and the calibration settings can be copied between [File](#) and [Buffer](#) spectrum windows. For this purpose, the [Copy ROI](#) and [Copy Calibration](#) commands may be used. Note that these operations destroy the corresponding settings in the destination. Once executed, these operations are not reversible. It is important that the spectrum soft size setting is the same for the source and the destination.

The [Copy ROI](#) → [File to Buffer](#) and [Copy Calibration](#) → [File to Buffer](#) commands can be used to recall the ROI and calibration data stored in spectrum files to the spectrum [Buffer](#).

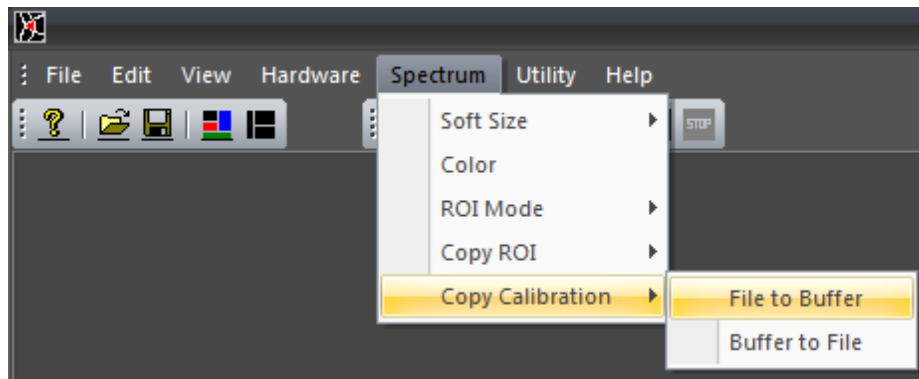


Figure 3.1.23. Spectrum menu → Copy Calibration options.

Utility

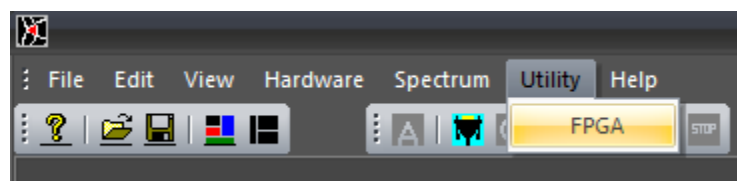


Figure 3.1.24. Utility menu.

The **Utility** menu has only one command: **FPGA**. The **FPGA** command is used to update the FPGA design of a connected nanoTDCR. If no device is connected to the **labZY-TDCR** software the **FPGA** command will issue a warning message and no further action will be performed.

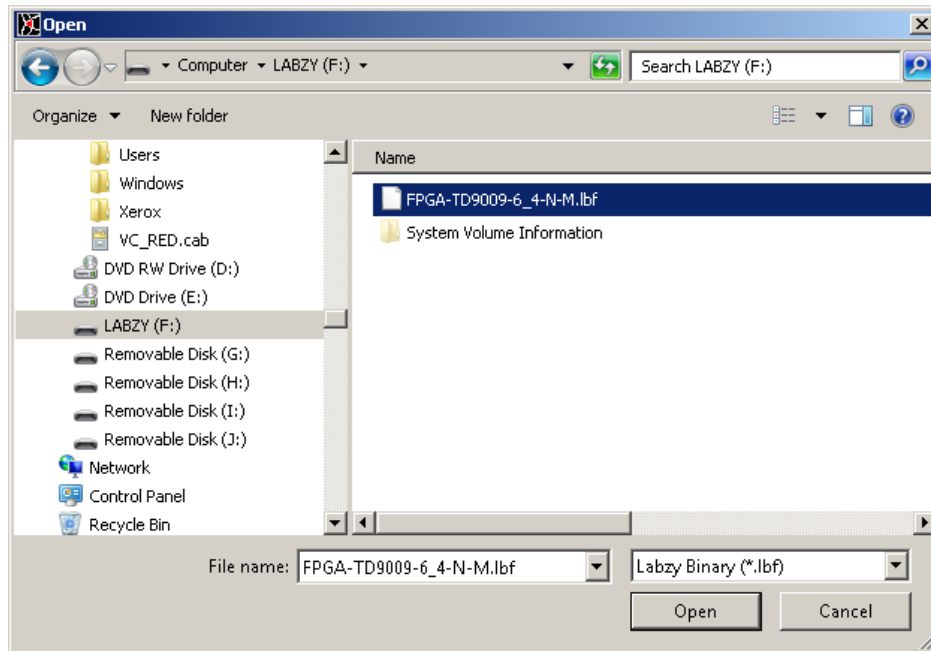
If a device is connected to the **labZY-TDCR** software the execution of the **FPGA** command will open a dialog (**FPGA**) that allows the upload of an FPGA design to the connected device.



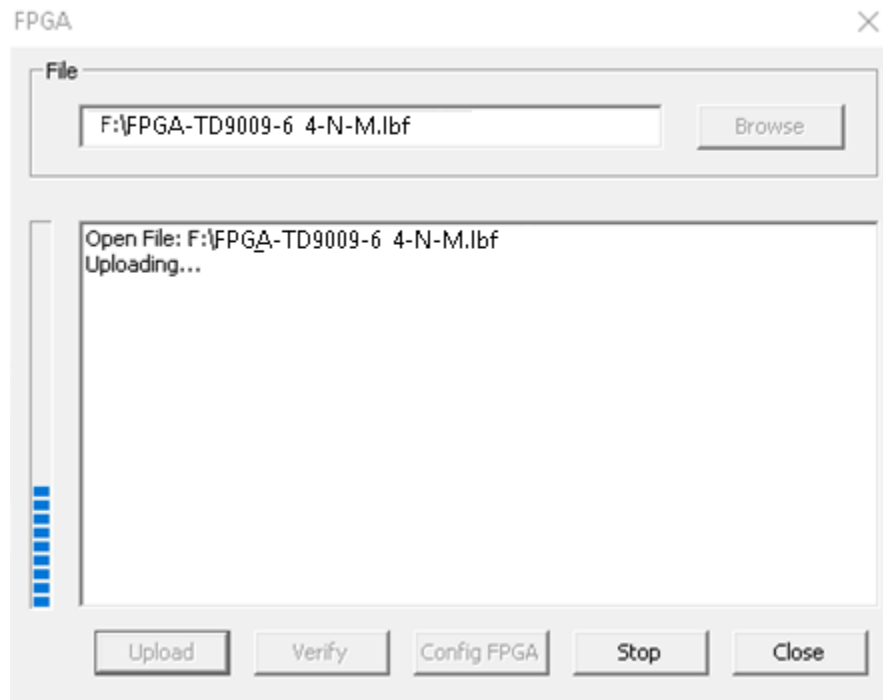
Figure 3.1.25. The **FPGA** dialog.

To upload an FPGA design, execute the following steps:

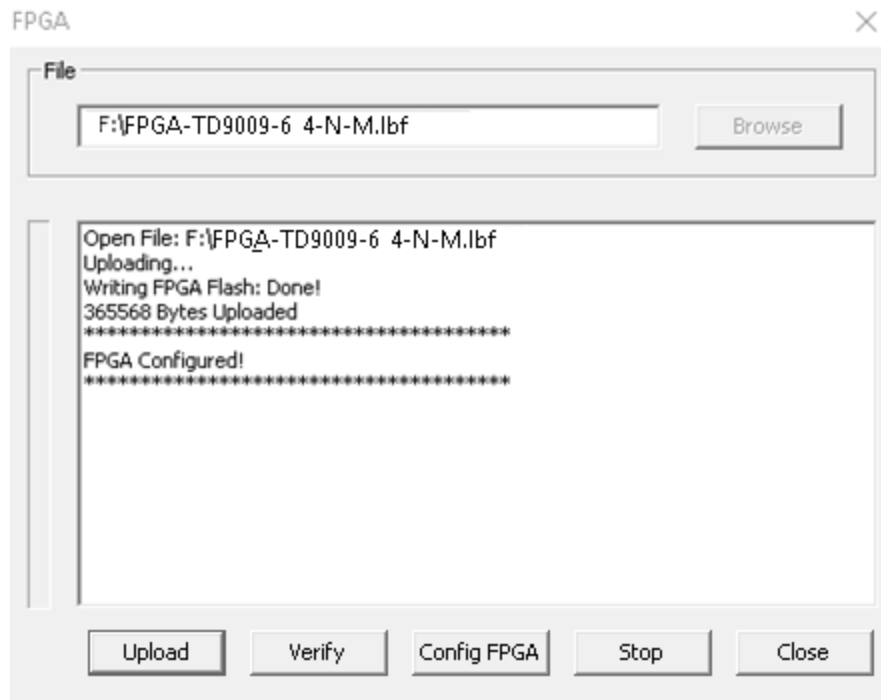
- 1) Press the button "**Browse**" to display the "**Open**" dialog. Browse to the directory of the FPGA design file with the extension "**.lbf**". Select the file and open it by pressing the "**Open**" button.



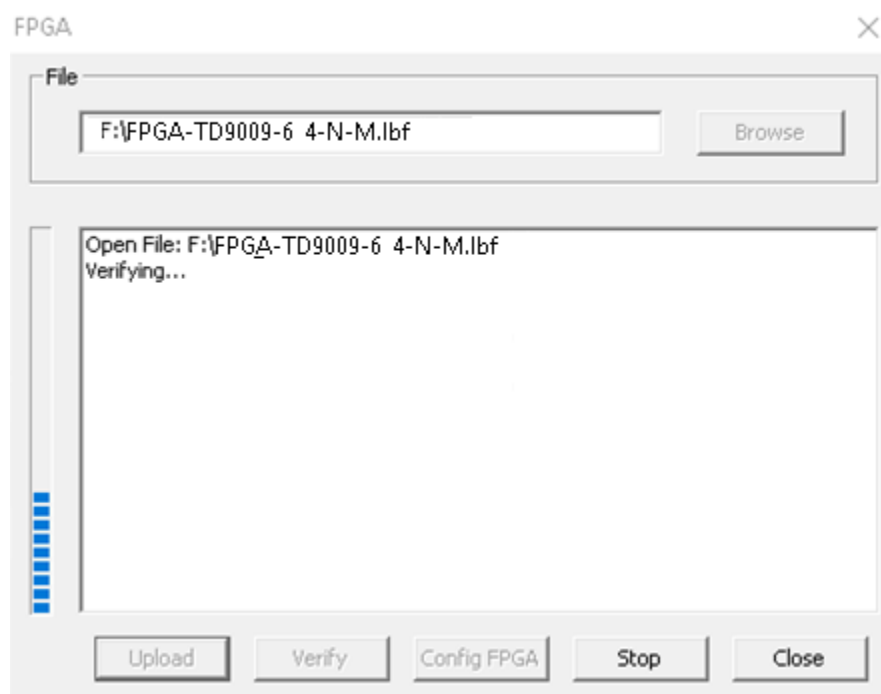
2) Press "**Upload**" and wait until the design programming file is uploaded. If the upload fails, repeat this step.



3) For the uploaded FPGA design to take effect either cycle the power of the nanoTDCR or execute the "**Config FPGA**" command. Cycling the power will save the current settings of the FPGA. "**Config FPGA**" will reload the settings of the FPGA from the last power on. The FPGA dialog after execution of Config FPGA is shown below.



4) The currently stored FPGA design in the nanoTDCR can be verified against an FPGA design file (.lbf) by executing the “**Verify**” command.



Help

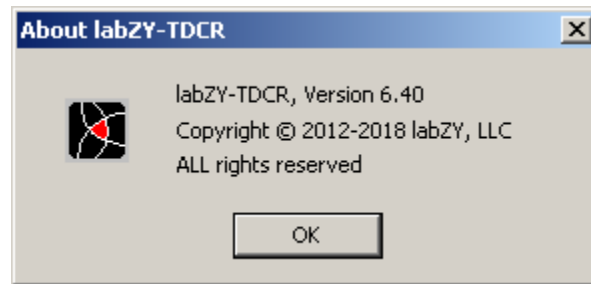


Figure 3.1.26. About labZY-TDCR window.

The [Help](#) menu provides version information about the labZY-TDCR software. There is no provision for interactive help topics at the time of writing this document.

Docking Windows

The display information and control functions of the labZY-TDCR software are contained within docking windows. Docking windows are not permanently attached to the frame of the labZY-TDCR application. Instead, they can be moved independently or in groups and positioned anywhere on the computer screen. The docking windows can be docked at the sides of the main frame of the labZY-TDCR application. When undocked, like any window, these windows can be resized. **To group docking windows into one tabbed window, drag them and align their title bars. To pull a tabbed window out of a tabbed group, grab the window tab and move it away from the group. To restore the last position of a window double, click the title bar.**

Spectrum Window

The [Spectrum Window](#) has two tabs. The first tab is the [Buffer](#) tab. When the [Buffer](#) tab is selected, the spectrum from the connected hardware device is displayed in the window. The content of the Buffer window is automatically updated by the hardware when the [Auto Update](#) button of the [Acquisition Window](#) is checked.

The [File](#) tab displays spectra loaded from files. When a spectrum is opened, the File tab is selected automatically. When the File tab is selected, all hardware controls are disabled, including the hardware related toolbar buttons.

To control the spectrum display or to move the cursor, the [Spectrum Window](#) must be selected by clicking the mouse within the window. The mouse, the keyboard, and the [View Control](#) device bar are used to adjust the appearance of the spectra (see Mouse and Keyboard Functions).

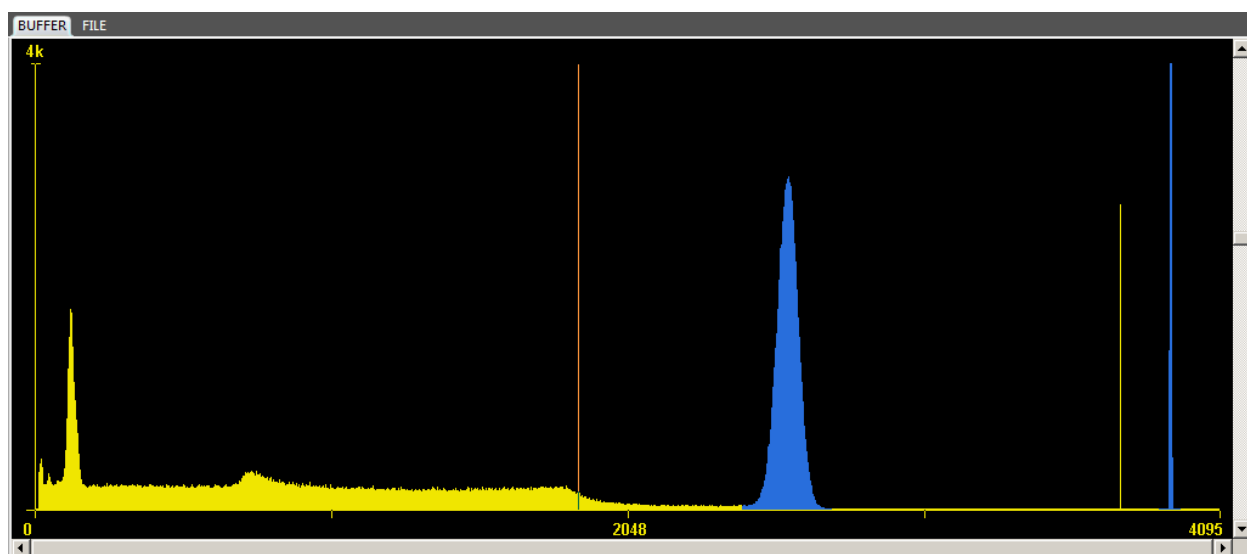


Figure 3.2.1. Sample display of a spectrum.

DPP Window

The DPP Window interface is divided into several sections:

- SLOW SHAPER:** RISE TIME [sa] 10, RISE TIME [us] 0.0800, FLAT TOP [sa] 10, FLAT TOP [us] 0.0800.
- FAST SHAPER:** RISE TIME [sa] 2, RISE TIME [us] 0.0160, FLAT TOP [sa] 1, FLAT TOP [us] 0.0080.
- UNFOLDING Input E:** LONG TC [rel] 529, LONG TC [us] 0.5290, SHORT TC [rel] 37, SHORT TC [ns] 37.0.
- GAIN NORMALIZATION:** ☒ AUTO, ☒ FINE, FACTOR 29, BDC 1.125, TRAPEZOIDAL.
- EST. THRESH. [chn]:** SLOW 11, FAST 36.
- THRESHOLD (0 = AUTO):** SLOW AUTO X 1, FAST AUTO X 3.25.
- BLR RESPONSE:** SLOW 50, FAST 50, ☒ SYM, ☐ ACC, ☐ SYM.
- PILE-UP REJECTOR:** ☒ ON, ☒ ENHANCED.

Figure 3.2.2. DPP Window.

The [DPP Window](#) contains various controls that are related to the Digital Pulse Processor (DPP). Using these controls, the appropriate registers of the nanoTDCR can be modified. Upon connection of a hardware to the labZY-TDCR application, the fields of the controls are updated with the values from the device's hardware. Changing the fields while the nanoTDCR is connected will also change the corresponding device's registers.

The labZY FPGA designs implement two digital shapers – [Slow](#) and [Fast](#). Both shapers synthesise trapezoidal pulses. The [Slow Shaper](#) is the main spectroscopy shaper. The controls in the DPP group [SLOW SHAPER](#) allow adjustment of the [Rise Time](#) and the [Flat Top](#) of the Slow Shaper. The [Rise Time](#) of this shaper should be adjusted to optimize the signal-to-noise ratio (energy resolution). The [Flat Top](#) is adjusted to accommodate signals with non-uniform rise time or to enhance the integration of the signals from scintillation detectors.

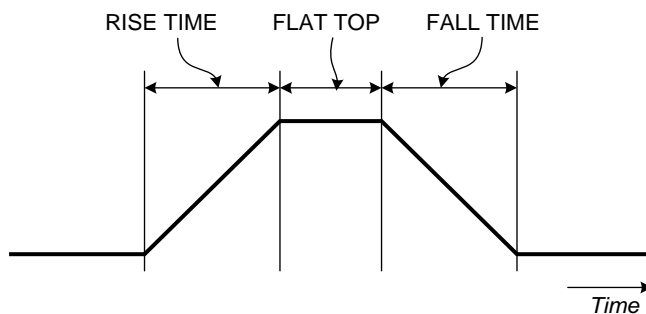


Figure 3.2.3. Trapezoidal pulses; FALL TIME = RISE TIME

The fast shaper parameters are set by the controls in the group [FAST SHAPER](#). The fast shaper is used to identify the presence of detector events and is used mainly for pile-up rejection. Thus, the rise time of the fast shaper is normally set to be much shorter than the rise time of the slow shaper. A [Rise Time](#) of 16ns to 200ns is typical for the fast shaper.

Both slow and fast shapers are equipped with low-level noise discriminators (LLD). The noise discriminator produces an active logic signal when the shaped signal is above a noise threshold. The group [THRESHOLD](#) contains the controls to set the noise discriminator thresholds. The thresholds for the slow shaper noise discriminator (SLOW LLD) and the fast shaper noise discriminator (FAST LLD) can be set manually by the edit controls [SLOW](#) and [FAST](#) respectively. Entering zero in these controls will set the noise thresholds in Automatic mode (AUTO). The [AUTO](#) mode is independently set for SLOW LLD and FAST LLD. It is recommended to use AUTO mode for both shapers. However, in some cases, a pickup of high frequency or fast rising signals may trigger the fast discriminator in AUTO mode causing increased dead time. In such cases, the threshold should be adjusted manually until the pick-up signals are rejected by the FAST LLD and the dead time is reduced. The [Auto Margin](#) control allows the addition of extra noise immunity to automatically set thresholds. The Auto Margins are ignored when the thresholds are set manually.

When the noise thresholds are in auto mode, the thresholds are set by the hardware internal noise estimation circuit. This circuit estimates the thresholds using a statistical technique based on a Gaussian probability density function of the noise distribution. The threshold estimation is shown in the group [EST. THRESHOLD](#), which are read-only controls. The estimated thresholds are always evaluated and displayed regardless of the threshold settings - Auto or Manual.

The DPP of the nanoTDCR is designed to accept exponential signals with two real poles characterized by a long time constant (LONG TC) and a short time constant (SHORT TC). The DPP has two functional stages. The first stage unfolds the input pulses by removing the two exponential responses corresponding to the two real poles of the signal. That is, the result of the unfolding function is a unit impulse. The unit impulse is fed to the second stage which performs a synthesis of trapezoidal/triangular pulse shapes.

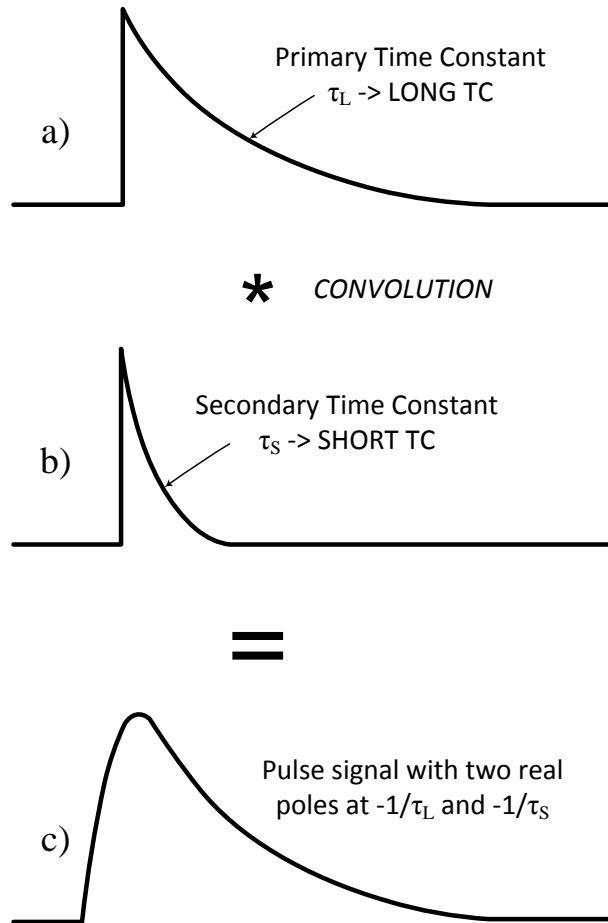


Figure 3.2.4. A pulse signal is characterized by LONG TC and SHORT TC.

The unfolding of the signals connected to inputs A, B and C has a common LONG TC and SHORT TC controls. The unfolding of the signals from Input E has separate controls for LONG TC and the SHORT TC. The current set of controls depends on the input selection in the SIGNALS window. The group UNFOLDING displays the current set of controls - UNFOLDING Input E or UNFOLDING Input ABC.

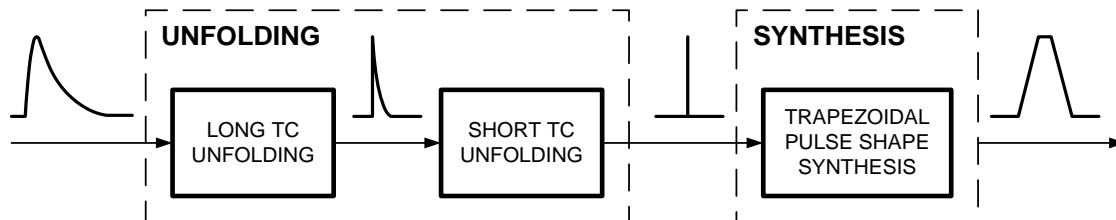


Figure 3.2.5. Unfolding to synthesis.

The LONG TC and the SHORT TC should be adjusted to minimize the tailing and/or the undershoot of the digitally shaped pulses (both the slow and fast shapers). SHORT TC has more influence on the fast shaper, while the LONG TC will affect both shapers. Adjustments of the time constants is performed using the [Trace Viewer](#).

The nanoTDCR is delivered with the LONG TC already adjusted to match the time constant of the internal shaping network for inputs A,B and C. The SHORT TC of Inputs A, B and C may need to be adjusted if the external signal sources have a rise time that is slower than the internal amplifier rise time.

The group UNFOLDING provides means for adjustment of the LONG TC and the SHORT TC. The controls are independent for Inputs A,B,C and Input E. These controls are automatically selected when the input of the nanoTDCR is selected in the [SIGNALS](#) window. The active Input ABC or E is indicated next to the group name [UNFOLDING](#).

The trapezoidal pulse shape synthesis can be represented as a convolution of two rectangular impulse responses. The peak value of the trapezoidal pulse represents the area under the shorter of the two rectangular impulse responses. The rise time of the trapezoidal pulse is equal to the width of the shorter rectangular impulse response. Therefore, the synthesis introduces gain equal to the rise time of the trapezoidal pulse shape. In addition, the ADC resolution differs from the total number of channels in the spectrum. These conditions require a normalization of the peaks of the digitally synthesized trapezoidal pulse shapes. The group [PEAK NORMALIZATION](#) presents a control for manual adjustment, the peak normalization FACTOR. Although this adjustment is available, it is strongly recommended to use the automatic normalization by checking the AUTO checkbox. The normalization FACTOR in auto mode is a linear function of the SLOW SHAPER rise time – $[FACTOR]=2.5[SLOW\ SHAPER]$. The FINE checkbox compensates for the difference of the LONG TC setting and the expected LONG TC, as coded into the FPGA design. It is safe to have both AUTO and FINE checked at the same time.

The ballistic deficit correction factor, BDC, is used to optimize the usage of the ADC range so that the signals are digitized by utilizing most of the ADC quantization levels. For fast rising signals (fast scintillators) the BDC should be set to 1. Setting BDC to 1 is always a safe choice. However, for optimum utilization of the ADC range the BDC can be adjusted (e.g. $Nal(Tl)$) using the [Trace Viewer](#). The adjustment procedure is described in *Appendix C*.

The [BLR RESPONSE](#) group controls the BLR of the SLOW and FAST shapers. The response of the BLR is inversely proportional to the value set for SLOW or FAST. A smaller number means more aggressive BLR. For moderate counting rates, the BLR response should be in the range of 200 to 500. For higher counting rates, the range should be between 20 to 200. The symmetric (SYM) mode of the BLR is recommended

for the SLOW shaper. Depending on the counting rates and the undershoots of the detector signals, the SYM mode will require careful evaluation to determine whether or not to use it.

The ACC mode of the BLR is a special mode when AC coupled detectors have non-linear response and cause severe undershoot when recovering from overload condition. This situation is rare and in most cases ACC will be left unchecked. When ACC is checked the BLR operates in fast recovery mode when overload caused by the detector signals is detected - the INHIBIT signal becomes active LOW. Fig. 3.2.6 depicts traces of ADC signal with undershoot, and the recovery of the slow shaper with and without engagement of the ACC. Avoid to use ACC mode unless the overload of the detector causes degradation of the resolution or a severe shift of the base line.

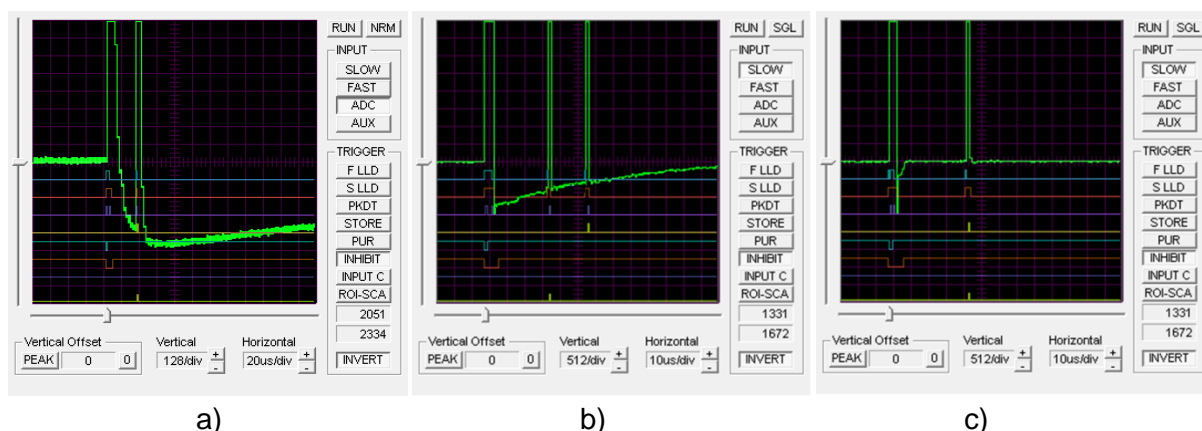


Figure 3.2.6. a) Overloaded detector signal; Slow Shaper - b) without ACC, c) with ACC.

The main function of the fast shaper, along with the FAST LLD, is pile-up rejection associated with the slow shaper. Note that the fast shaper pulses are also subject to pile-up. When such pile-up occurs, the FAST LLD pulses will be treated as a single event pulse and pile-up rejection will fail.

To improve the pile-up capability of the fast discriminator, a **pulse-shape analysis** of the fast pulse shape is performed (Fig. 3.2.7). The pile-up rejection capability of the nanoTDCR can be improved by checking the **ENHANCED** checkbox in the **PILE-UP Rejector** group. The enhanced pile-up rejection algorithm does not use timing information and is not sensitive to pulse-tailing. In rare cases the ENHANCED pile-up rejection may be sensitive to high frequency pick-up signals.

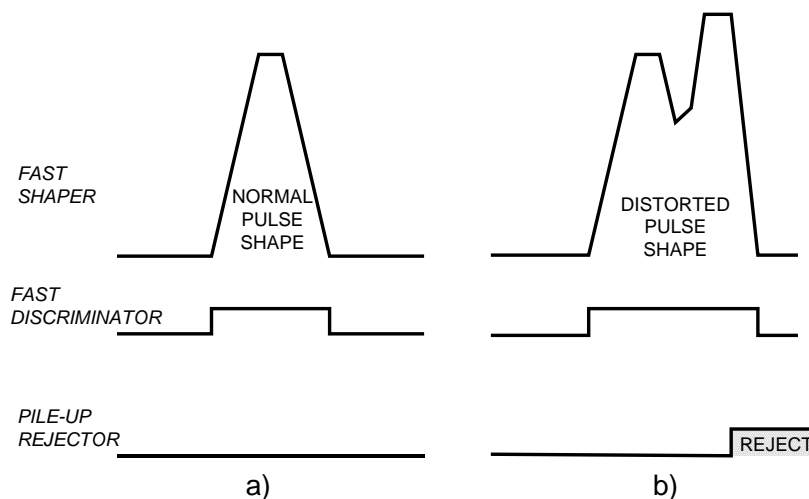


Figure 3.2.7. a) Pile-up free fast shaper/discriminator; b) fast shaper pile-up and pulse-shape distortion.

Fig. 3.2.8 illustrates normal pile-up rejection (a) and enhanced pile-up rejection (b) as seen by the [Trace Viewer](#). The signal trace depicts the fast pulse shape. The [Trace Viewer](#) is triggered by the internal pile-up rejector signal which has an active low logic level.

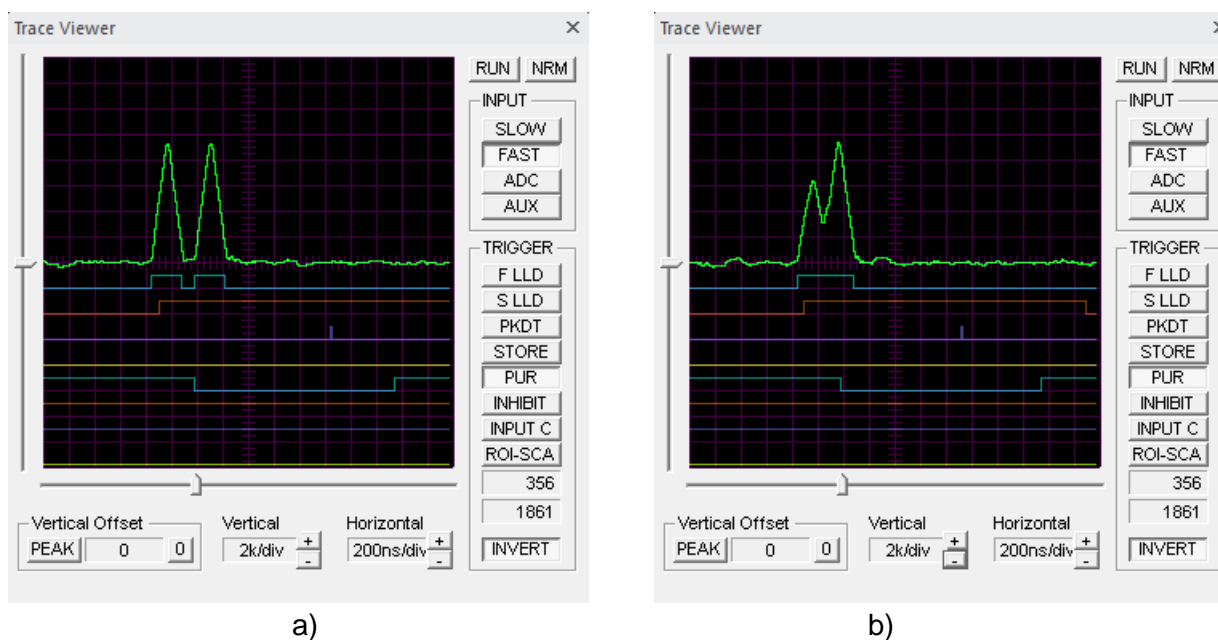


Figure 3.2.8. a) Traditional pile-up rejection; b) enhanced pile-up rejection.

SIGNALS Window

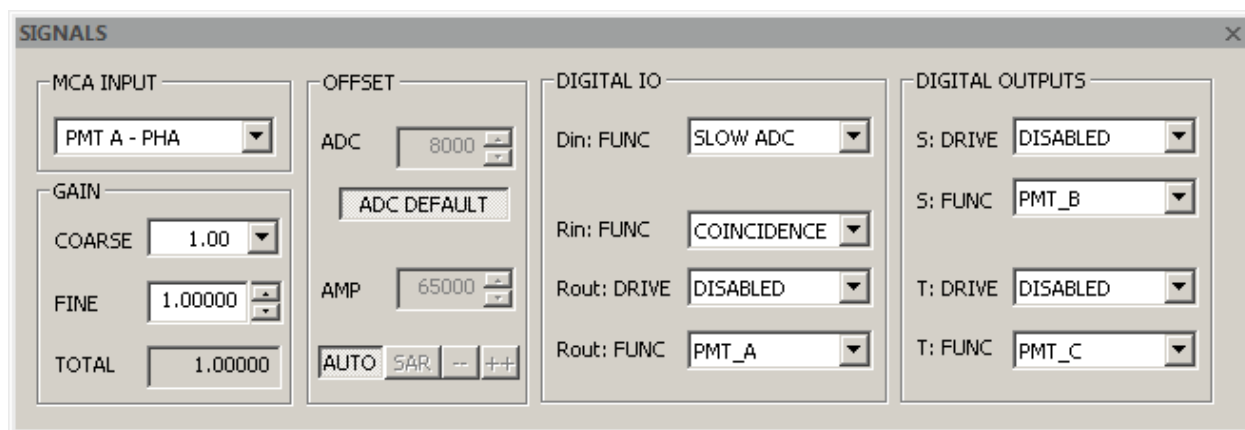


Figure 3.2.9. SIGNALS Window.

The [SIGNALS Window](#) contains the controls of the analog signals, analog signals-related functions, and configuration of the logic signals functions of the nanoTDCR.

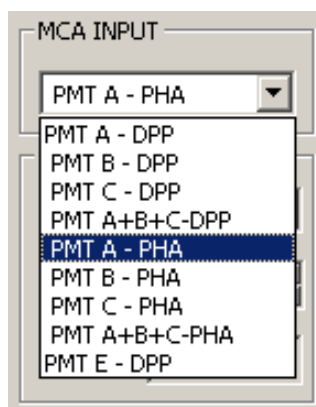


Figure 3.2.10. Analog Inputs A/B options.

The group [MCA INPUT](#) allows selection of the active input and the MCA mode of operation. Signals from inputs A,B and C can be processed by either DPP unit (digital shaper) of the MCA or the PHA unit (pulse-height measurement of the analog-shaped pulses). The signal from Input E is only processed by the DPP unit of the MCA. IMPORTANT: Input A, B and C share the same MCA memory (spectrum channels). Spectra from Input E are recorded in a separate memory. All controls of DPP and PHA are common for all inputs except the LONG TC and SHORT TC as described earlier.

The **DIGITAL IO** group contains controls for the digital IO functionality.

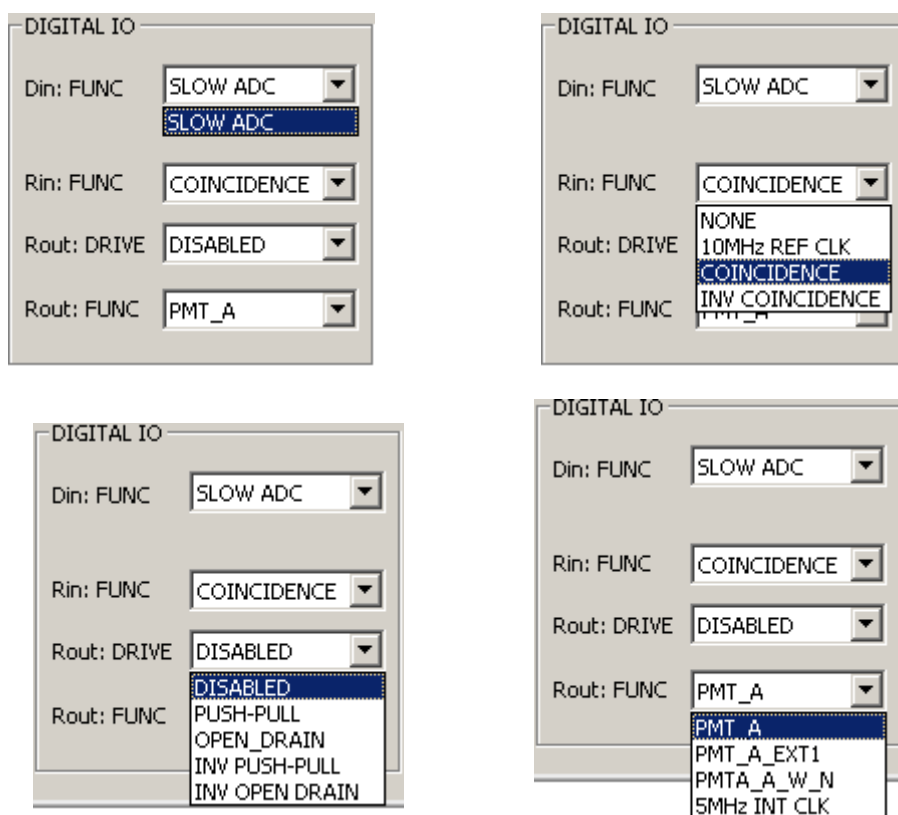


Figure 3.2.11. DIGITAL IO options.

Signal (Input) D can accept analog signals only. The analog signals applied to this input are digitized by a slow ADC. **Do not apply pulse signals or high frequency signals to Input D! For best performance of the nanoTDCR, Input D should be left open.**

The digital signal R is an input/output signal. Input R can be used as a source for coincidence/anticoincidence. A 10 MHz reference clock (traceable) can be applied to Input R and can be used in real time for calibration of the internal clock of the nanoTDCR.

The signal R can also be used as an output. The signal R output function is automatically disabled when signal R is enabled as an input. It is important that the R signal is not driven by an external signal when it is set as an output as this may cause a permanent damage to nanoTDCR.

The **DIGITAL OUTPUTS** group contains controls for the digital outputs of the nanoTDCR.

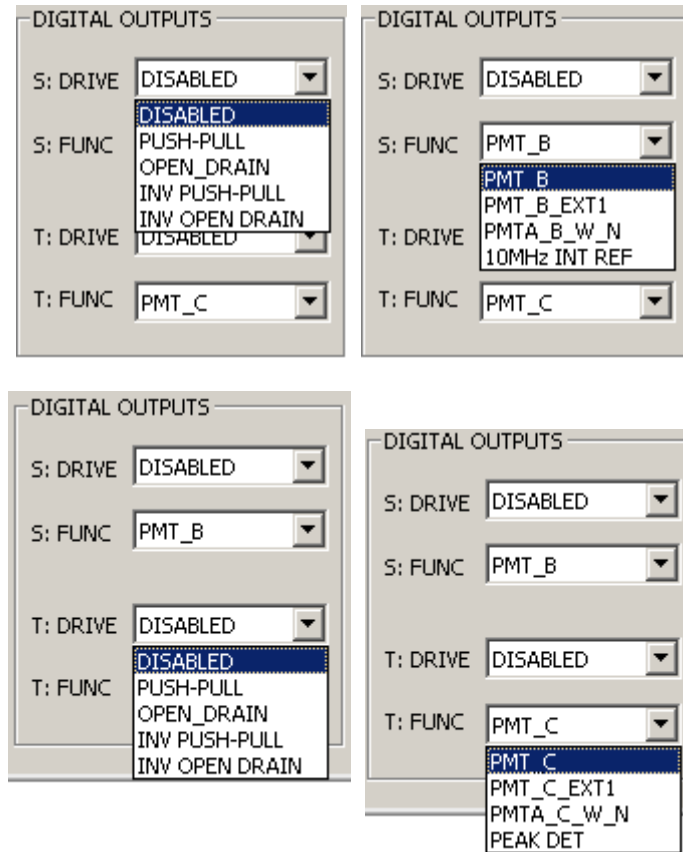


Figure 3.2.12. DIGITAL OUTPUTS configuration options.

The **OFFSET** group relates to, and is of extreme importance for, the operation of the ADC and DPP. Offsets are especially important for the proper operation of the **ADC**. The offset concept and associated requirements are completely different from the old understanding and requirements used in analog based pulse shapers and spectroscopy ADC. **IMPORTANT! The "zero offset" of the recorded spectra is not affected by these offsets. These are signal processing related offsets only.** An offset at the input of the ADC allows digitization of the negative portion of the noise. The analog offset at the input of the ADC is referred to as the **AMPLIFIER OFFSET**. The digital offset that is subtracted from the digitized signal is the **ADC OFFSET**. The AMPLIFIER OFFSET should be adjusted so that its digital equivalent is cancelled out by the ADC OFFSET.

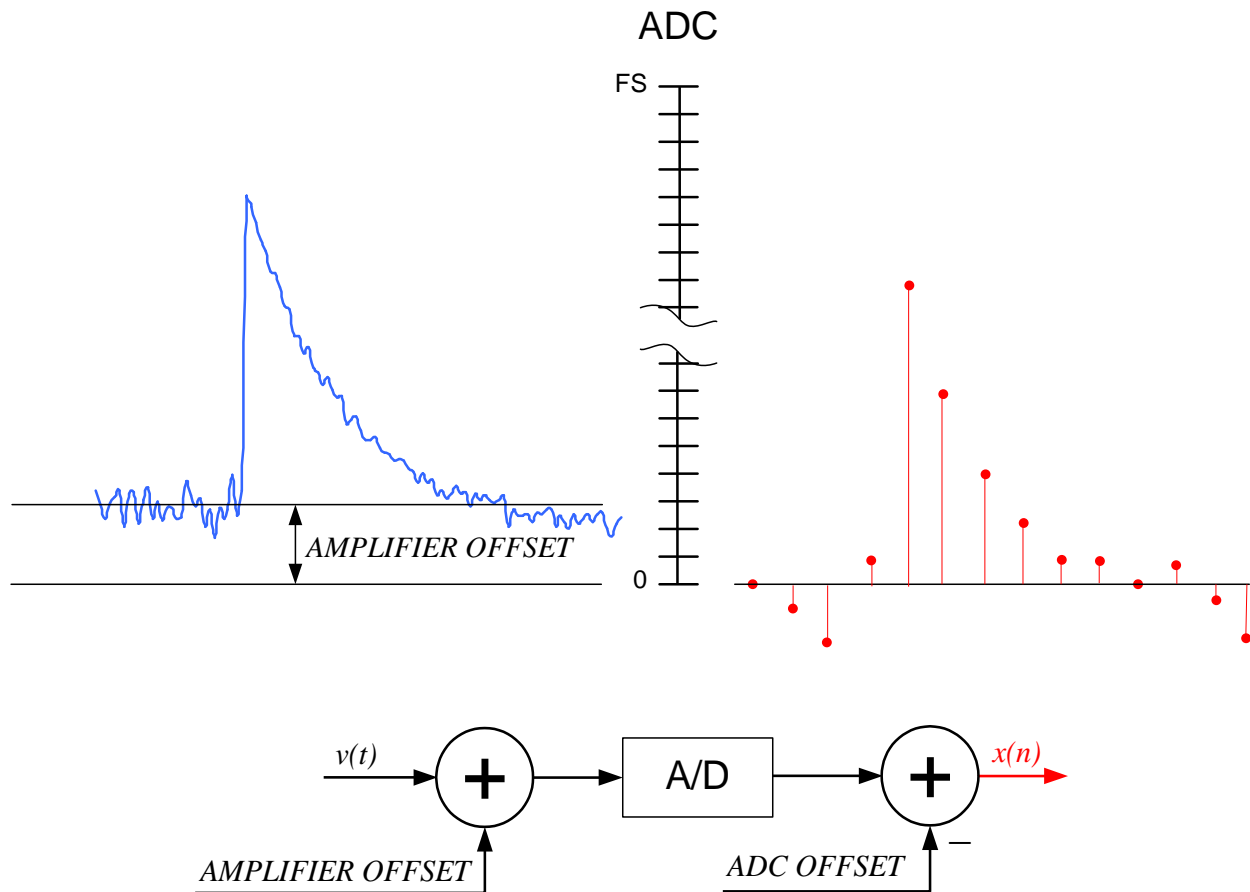


Figure 3.2.13. Offset cancellation.

It is recommended that both the ADC DEFAULT and the AUTO options are used, and the corresponding ADC DEFAULT and AUTO buttons are depressed. The labZY hardware incorporates automatic adjustment of the AMPLIFIER OFFSET so that it can be cancelled exactly by the ADC OFFSET.

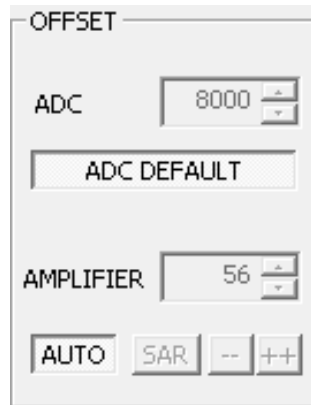


Figure 3.2.14. Offset group.

Some measurements (e.g. the PHA of bipolar signals) may require manual adjustment of the **AMPLIFIER OFFSET**. To manually adjust the **AMPLIFIER OFFSET**, use the Trace Viewer window and the SAR button of the **OFFSET** group. **Be sure to remove any radiation sources and to reduce the counting rate to as low as possible before making any adjustments.** In the **Trace Viewer** window, set the **Acquisition Mode** to RND, the **Horizontal** setting to 20 $\mu\text{s}/\text{div}$, the **Vertical** setting to 4k/div, and the **Vertical Offset** setting to zero (press the “0” button). Then select **ADC** in the Input section and press the **RUN** button of the Trace Viewer.

In the **OFFSET** section of the **SIGNALS Window**, turn **AUTO** off and press the **SAR** button. The **AUTO** button will become inactive (grayed out). Observe the ADC trace in the Trace Viewer window. The ADC trace will shift upwards or downwards. The goal is to adjust the position of the ADC trace to the middle of the window. If the ADC trace is above the zero line (aligned with the Offset pointer), press the “--” button of the **OFFSET** section in the **SIGNALS Window**. If the ADC trace is below the zero line, press the “++” button. After pressing either button, wait at least five seconds until the ADC trace settles. Continue the sequence of pressing the “--” and “++” buttons according to the position of the ADC trace until the **SAR** button becomes active and the “--” and “++” buttons are greyed out. You may terminate this procedure by pressing the **AUTO** button. You may need to adjust the **Vertical Offset** for more precise adjustments of the Amplifier OFFSET. The Amplifier OFFSET may be fine-tuned by modifying the offset value in the **AMPLIFIER** edit box. **For more information about offset adjustments**, please visit the support section of labzy.com.

The **GAIN** group has controls to adjust the analog gain. The **COARSE** gain is adjusted in steps. There are only 4 coarse gain settings defined as $2^{N/2}$, where $N = 0$ to 3.

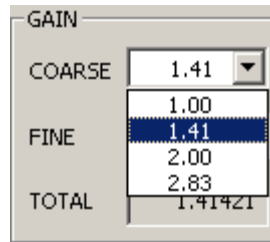


Figure 3.2.15. Coarse Gain selection.

The **FINE** control can be used to fine-tune the analog gain. The range of the fine gain is from 1 to 1.2, adjustable in 65536 steps. Thus, for Input A, the analog gain is virtually continuous covering a range from 1 to 255. The read-only TOTAL field reports the total analog gain by multiplying the fine gain and the coarse gain.

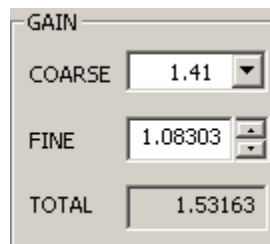


Figure 3.2.16. The fine gain control and the total gain field.

PHA Window

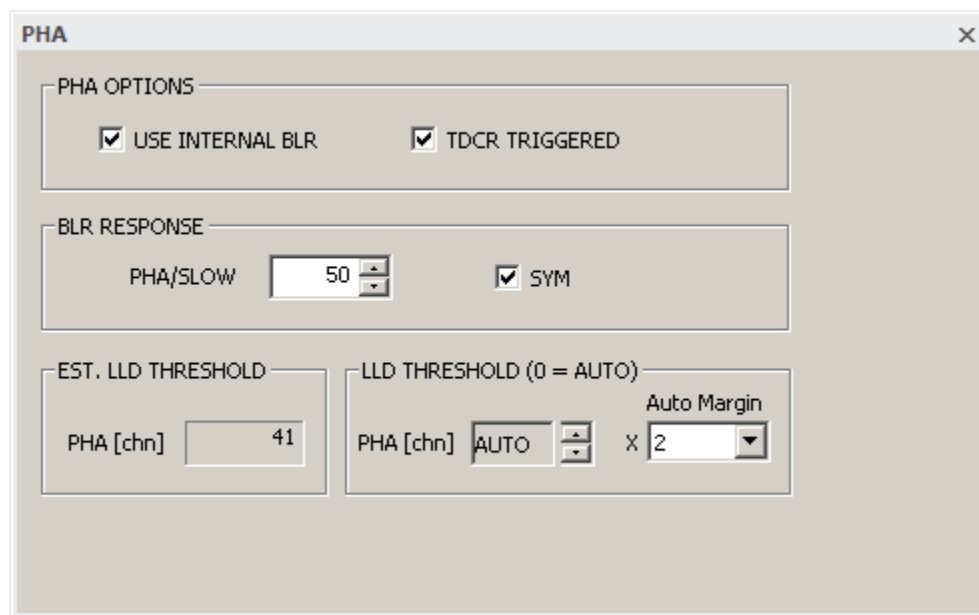


Figure 3.2.20. PHA Window

The [PHA Window](#) is only available for the MCA Inputs A,B and C in PHA mode. It is recommended to use the internal BLR with a response set to 50 with the SYM box checked as depicted in Fig. 3.2.20. The pulse-height measurement can be triggered by internal low level discriminator or by the TDCR discriminators at inputs A, B, C. When TDCR triggered the spectrum of the corresponding input (A,B or C) will acquire pulse-heights of pulses that exceeds the TDCR threshold. That is, an adjustment of the TDCR threshold will affect the lower cut-off of the spectrum. This is especially useful to adjust the TDCR threshold just below the single photon response of the PMT. For more information refer to the application information in the nanoTDCR data sheet.

The LLD threshold is used by the internal BLR and should be adjusted properly. Auto mode and margin of 1 is a typical setting.

Acquisition Window

The **ACQUISITION Window** contains the spectrum acquisition parameters and acquisition control settings.

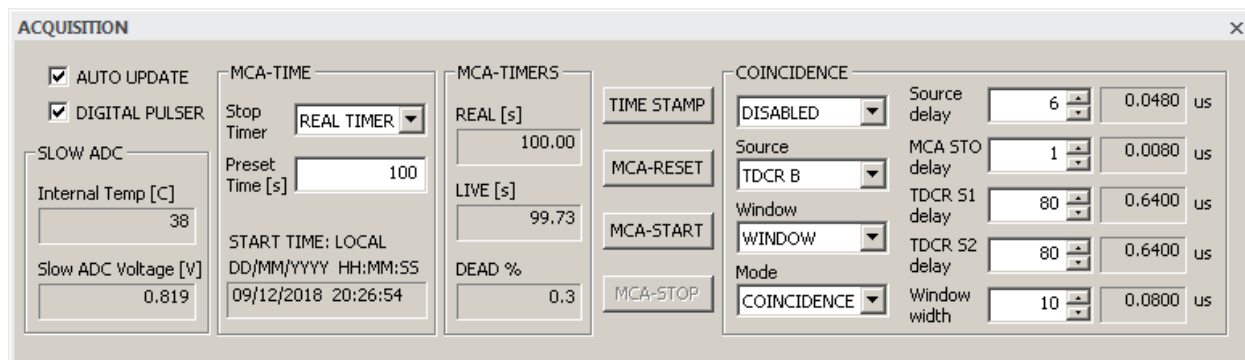


Figure 3.2.16. Acquisition Window.

The **AUTO UPDATE** checkbox controls the data exchange between the labZY-TDCR software and the connected hardware. To continually update all data from the hardware, this checkbox must be selected. When the **Trace Viewer** is in acquisition state, this box is automatically unchecked to improve the update rate of the Trace Viewer. It is possible to recheck the box while the Trace Viewer is acquiring data; however, the update rate of the spectrum and the Trace Viewer will be reduced noticeably.

Selecting the **DIGITAL PULSER** will enable the hardware built-in digital pulser. The digital pulser data is stored in channels 3752 to 4095 of the hardware spectrum. When the digital pulser is enabled, the spectrum is stored in channels 0 to 3751. The centroid of the digital pulser peak is offset relative to the spectrum zero channel by 3923 channels. This offset can be used to assess baseline offsets.

The preset time of the spectrum acquisition is set by the controls in the group **MCA-TIME**. The preset time can be either **LIVE TIME** or **REAL TIME** depending on the selected stop timer. The preset time can be set in seconds. The **MCA-TIMERS** group reports the elapsed real and live time. The dead time is also reported.

The spectrum acquisition is controlled by the following buttons: **MCA-START**, **MCA-STOP**, **MCA-RESET**. These buttons are also available as buttons of the **HARDWARE CONTROL** toolbar.

The **TIME STAMP** button opens a dialog to select a time stamp for a given measurement.

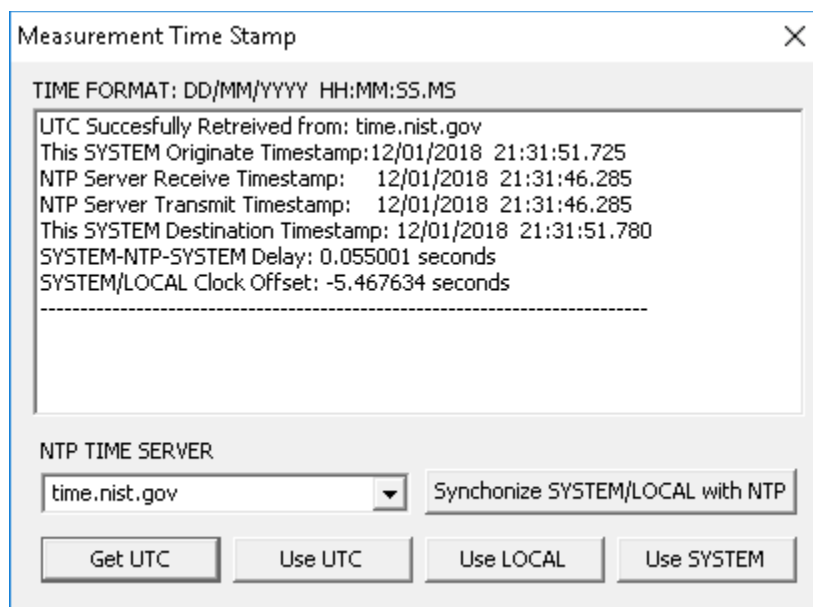


Figure 3.2.20. Timestamp Dialog.

The time stamp may use UTC, LOCAL or SYSTEM time. the UTC can be obtained from an internet time server with an accuracy of less than 50ms. The time stamp stored in the hardware will be with an accuracy of 1s. If UTC is selected, the labZY-TDCR software will automatically open the dialog seen in Figure 3.2.20 when selecting START or RESET if more than 300s have expired from the last internet time synchronization with an NTP time server. It is possible to synchronize a local host clock with the obtained NTP time; this function, however requires that the labZY-TDCR is run with administrator privileges (run as administrator).

The **COINCIDENCE** group is used to set-up the coincidence/anticoincidence function of the nanoTDCR.

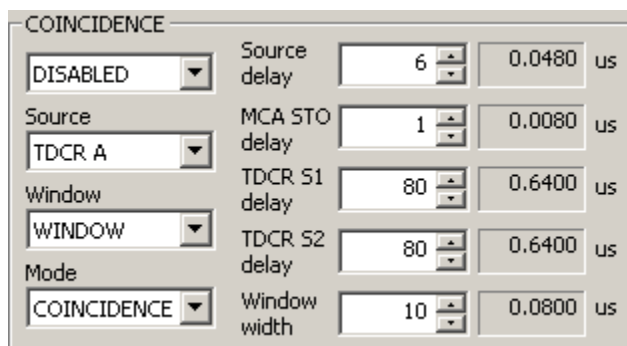


Figure 3.2.21. Coincidence Controls.

The nanoTDCR supports two independent coincidence/anticoincidence data acquisition systems. The first system controls the acquisition of MCA spectra and the second controls the TDCR set of counters.

The screenshot shows the 'COINCIDENCE' dialog box with the following settings:

Parameter	Value	Unit
Source delay	6	0.0480 us
MCA STO delay	1	0.0080 us
TDCR S1 delay	80	0.6400 us
TDCR S2 delay	80	0.6400 us
Window width	10	0.0800 us

The 'Mode' dropdown is set to 'COINCIDENCE'. The 'MCA' option is selected in the main dropdown menu.

a)

The screenshot shows the 'COINCIDENCE' dialog box with the following settings:

Parameter	Value	Unit
Source delay	6	0.0480 us
MCA STO delay	1	0.0080 us
TDCR S1 delay	80	0.6400 us
TDCR S2 delay	80	0.6400 us
Window width	10	0.0800 us

The 'Mode' dropdown is set to 'COINCIDENCE'. The 'TDCR-EXT1&2' option is selected in the main dropdown menu.

b)

Figure 3.2.22. Selection of the coincidence/anticoincidence data acquisition system -

a) MCA; b) TDCR.

For more information about coincidence/anticoincidence features refer to nanoTDCR data sheet.

Calibration Window

Calibration [X]

☒ **ENABLE CALIBRATION**

CHANNEL: 12162 ENERGY: 1460

PEAK keV [v]

CURSOR ADD POINT

CALIBRATION POINTS

	Channel	Energy
<input type="checkbox"/>	0.00	0.0000
<input checked="" type="checkbox"/>	2922.25	352.0000
<input checked="" type="checkbox"/>	5060.42	609.0000
<input checked="" type="checkbox"/>	14714.00	1764.0000

Edit Selected Points

Remove Selected Points

Remove All Points

Calibrate with Selected Points

Calibrate with All Points

EN = $aCH^2 + bCH + c$

CALIBRATION w/ SELECTED

a = -0.0000
b = 0.1206
c = -0.0000

The **Calibration Window** contains the energy calibration settings. The labZY-TDCR device utilizes up to 10 points to conduct a second-order calibration. This calibration uses selected channel-energy points to solve for the coefficients **a**, **b**, and **c** of the equation: $EN = aCH^2 + bCH + c$.

To set the calibration coefficients, up to 10 channel-energy points can be used. The available points are listed in the **CALIBRATION POINTS** table. Selecting (check-marking) a subset of the **CALIBRATION POINTS** and clicking **Calibrate with Selected Points** will calibrate the spectrum using the selected points only.

Alternatively, clicking **Calibrate with All Points** will conduct the calibration using all points listed in the **CALIBRATION POINTS** table. Note that at least two points are required for calibration.

Channel-energy points can be added to the **CALIBRATION POINTS** table via the **CHANNEL** and **ENERGY** interfaces. The entry of the **CHANNEL** data can be manual, by ROI **PEAK** centroid, or by **CURSOR** position, while the **ENERGY** values must be entered manually. To enter a **PEAK** centroid **CHANNEL**, select an ROI of a spectral peak in the spectrum window, place the spectrum cursor within the ROI using the left mouse button, and press the **PEAK** button. To enter a **CURSOR** position, move the spectrum cursor to the desired channel in the spectrum window by pressing the left mouse button, and press the **CURSOR** button. Press **ADD POINT** to transfer the **CHANNEL/ENERGY** values as a calibration point to the **CALIBRATION POINTS** table.

To edit calibration points, select (check-mark) the points to be edited and press the **Edit Selected Points** button once. This will populate the **CHANNEL/ENERGY** fields with the first selected point in the table, while simultaneously removing that point from the table. Edit the **CHANNEL/ENERGY** fields as desired, and click **ADD POINT** to add the new, edited point to the calibration points table. Repeat this process until all selected points have been edited.

Calibration points can be removed by first selecting the relevant points (check-marking) and then pressing the **Remove Selected Points** button. Clicking **Remove All Points** will remove all calibration points from the table.

Figure 3.2.23. Calibration

The calibration units are selected from the drop-down choice list. Checking the **ENABLE CALIBRATION** box will display the spectrum information in calibration units.

Spectrum Info Window

The [Spectrum Info Window](#) displays read-only information about the spectra and acquisition-related information.

The [CURSOR](#) group displays the position of the spectrum cursor in channels or calibration units. The counts of the channel at the cursor position are also reported.

The [PEAK INFO](#) group provides peak info when the spectrum cursor is within an ROI marking a spectral peak. The [CENTROID](#), [FWHM](#) and [FWTM](#) are displayed either in channels or in calibration units.

The [TIME](#) group displays the state of the hardware timers. This information is also available as part of the [Acquisition Window](#). The [Dead Time](#) is calculated based on the total elapsed time. The reported Dead Time will not change when the spectrum acquisition is stopped.

The [COUNT RATE](#) group provides life information independent of the spectrum acquisition state. The [counting losses](#) are an indication of the dead time on a short time scale. At low counting rates, the reported losses may show large variations due to statistical fluctuations. For accurate measurement of the [Dead Time](#), the Dead Time reported in the TIME group should be used.

The [INCOMING](#) count rate is derived from the fast discriminator counting rate corrected for the pile-up losses. The correction is based on the parameters of the fast shaper and the counting statistic. Caution should be exercised when interpreting the counting losses of periodic test signals as their time intervals are not randomly distributed. Incorrect setup of the coincidence circuit or the inhibit signal may cause very large counting losses, approaching 100%. Similarly, very low noise thresholds may cause the fast discriminator to respond to noise, which will also lead to increased counting losses.

The [CAL](#) check box mirrors the functionality of the [Enable Calibration](#) check box of the [Calibration Window](#).

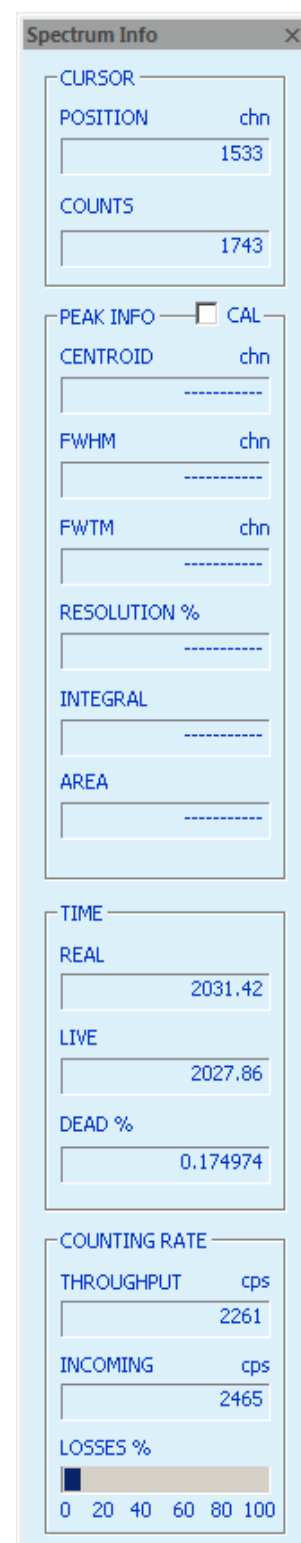


Figure 3.2.24. Spectrum Info

Trace Viewer Window

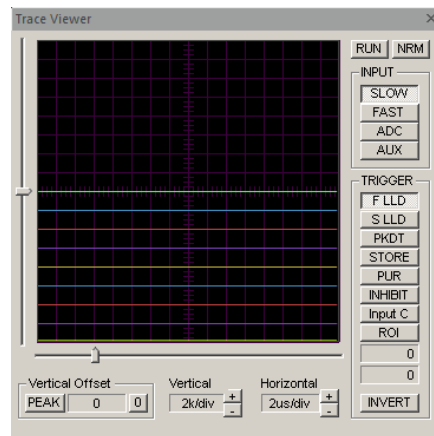


Figure 3.2.19. Normal size Trace Viewer Window.

The [Trace Viewer](#) acts as a mixed signal oscilloscope and can be used to set and verify parameters, to debug hardware configurations and FPGA designs, and to investigate detector signal features.

The Trace Viewer is a docking window and can be resized. The resizing, however, differs from the resizing of the other docking windows. The Trace Viewer can be displayed in only two sizes – normal and large. When resizing from normal to large, the sizing will take effect if the size of the window frame exceeds the large. When sizing down to normal size, the sizing will take effect if the size of the frame becomes smaller than the normal size.

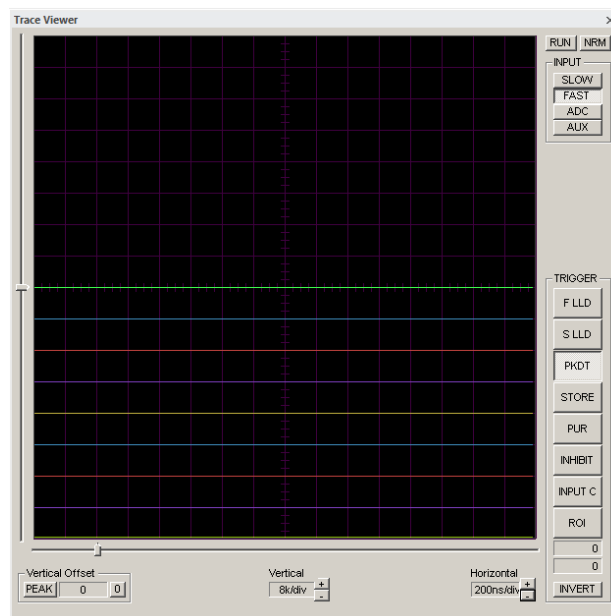


Figure 3.2.20. Large Size Trace Viewer Window

The Trace Viewer is a hybrid solution using hardware resources and software functions to capture and display one digital signal waveform and eight logic signal traces. The Trace Viewer includes various controls for setting the hardware and selecting the software features.

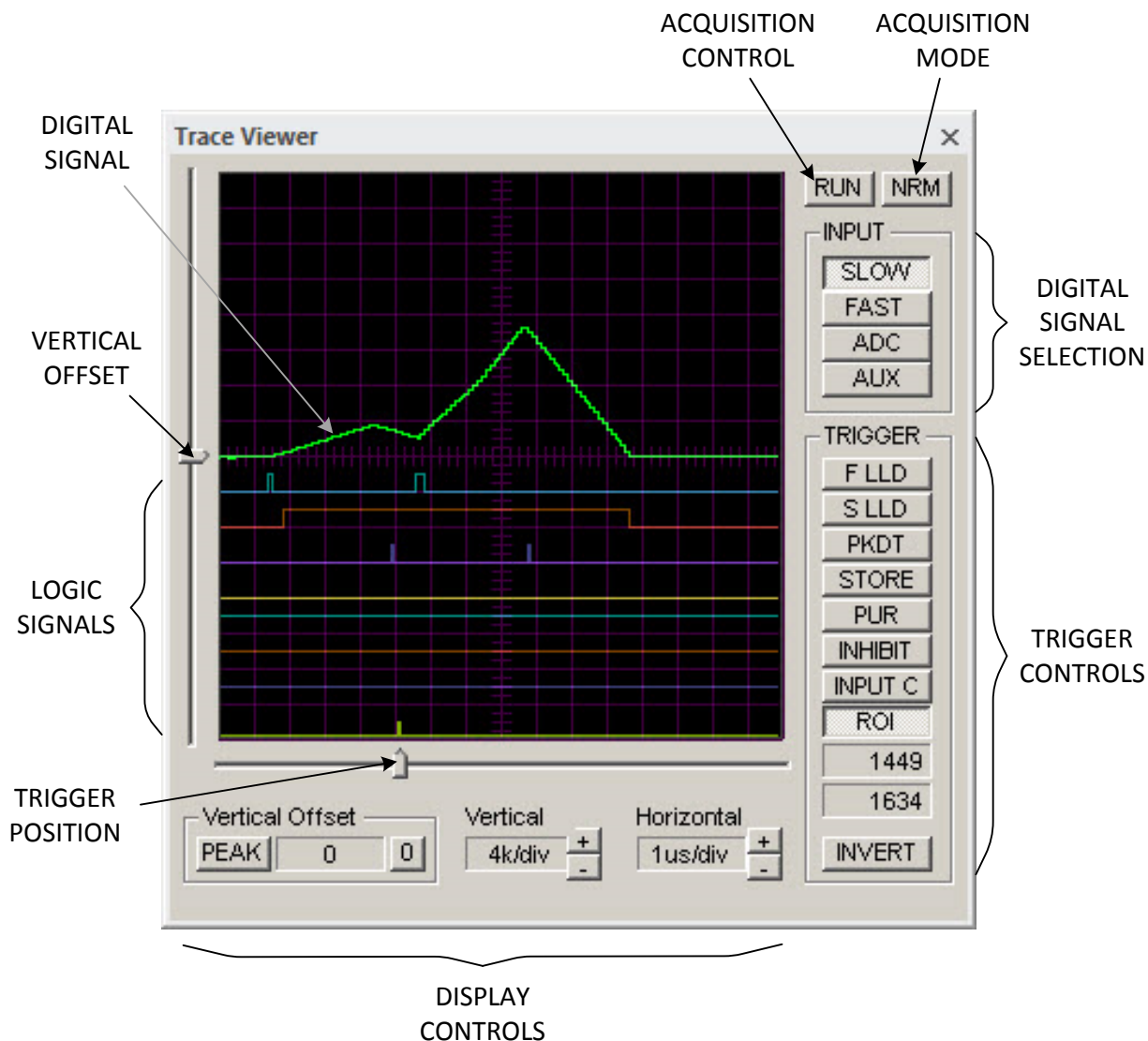


Figure 3.2.21. Controls and features of the Trace Viewer.

The trace display window displays the **digitals signal** and the **logic signals**. The position of the logic signals is fixed. The digital signal can be displayed with an offset that is selected within the trace display window by the **VERTICAL OFFSET** control. The vertical offset can be reset to zero by pressing the zero button **0** in the Vertical Offset group.

The horizontal time scale can be selected using the [Horizontal](#) control by pressing the + or – buttons. The vertical scale is chosen from preset values by pressing the + or – buttons of the [Vertical](#) control.

The trace acquisition is controlled by two buttons: [ACQUISITION CONTROL](#) and [ACQUISITION MODE](#). There are seven acquisition modes that can be selected by consecutively pressing the ACQUISITION MODE button.

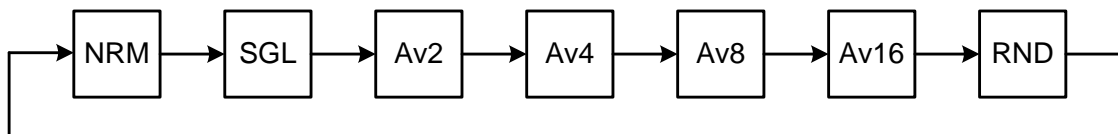









Figure 3.2.22. Acquisition Mode selection sequence using the ACQUISITION MODE button

The selected acquisition mode is displayed as a caption of the ACQUISITION MODE button:

-  *Continuous, triggered acquisition. No averaging of the digital signal.*
-  *Single, triggered acquisition. No averaging of the digital signal.*
-  *Continuous, triggered acquisition. 2 samples averaging of the digital signal.*
-  *Continuous, triggered acquisition. 4 samples averaging of the digital signal.*
-  *Continuous, triggered acquisition. 8 samples averaging of the digital signal.*
-  *Continuous, triggered acquisition. 16 samples averaging of the digital signal.*
-  *Continuous, random acquisition.*

The [Trace Viewer](#) can be in three acquisition states: stopped, continuous acquisition and single acquisition. When the hardware is not connected, the Trace Viewer is always in the stopped state. In the stopped state, the ACQUISITION CONTROL caption displays “[RUN](#)”. To enter the acquisition states, a connection with the hardware must be established.

The single acquisition state is entered by pressing the ACQUISITION CONTROL button when its caption displays “[RUN](#)” and the acquisition mode is [SGL](#). After this, the ACQUISITION CONTROL button will remain depressed and its caption will change to “[ACQ](#)”. After the single trace acquisition is recorded, the Trace Viewer re-enters the stopped state.

The continuous acquisition state is entered by pressing the ACQUISITION CONTROL button when its caption displays “RUN” and the acquisition mode is not SGL. The caption of the ACQUISITION CONTROL button changes to “STP” and remains pressed. To exit the continuous acquisition state, press the depressed ACQUISITION CONTROL button when its caption displays “STP”.

The **Trace Viewer** displays one digital signal waveform, which can be selected from four different sources. The selection of the digital signal is done by depressing one of the four buttons in the Input group. **SLOW** is the slow shaper signal, **FAST** is the fast shaper signal, **ADC** is the digitized analog signal after the subtraction of the **ADC OFFSET**. **AUX** is the same as SLOW in the standard nanoTDCR. AUX can be connected to other internal digital signals in customized designs.

The **Trigger** group contains controls to select trigger source for continuous or single triggered acquisitions. The trigger can be selected only from the logic signals. The **INVERT** button defines the trigger edge. When this button is not depressed, the low-to-high transition of the trigger signal is the acquisition trigger edge for all traces. When the button is depressed, the high-to-low transition is the trigger edge.

The trigger source can be selected by depressing one of the eight trigger buttons in-line with the logic signal traces. The captions of these buttons also serve as labels for the logic signal traces. The **F LLD** and **S LLD** are the fast and the slow low-level discriminators, respectively. The **PKDT** is the peak detection logic strobe signal. The **STORE** is the signal that triggers increments of the channels. **PUR** is the pile-up rejection logic signal. **INHIBIT** is the internal inhibit signal, which disables the base-line restorer and the spectrum acquisition. INHIBIT is generated not only when Input C is active, but also when the ADC overflows. The INHIBIT button may change to **COINC W** (coincidence window) button depending on the state of **Input C** button. The Input C button is a dual-purpose button: when depressed and clicked, this button changes its own functionality as well as the functionality of the INHIBIT/COINC W button. There are two pairs of button options, indicated by the corresponding button options: the first pair is Input C + INHIBIT and the second pair is Input D + COINC W. This allows a total of ten logic signals to be used as triggers and their traces displayed.

The **ROI** trigger is a very special and useful option, allowing triggering by events with pulse heights corresponding either to a range of channels, or to a single channel. When using the ROI trigger, one can identify the cause of anomalies in the spectrum by simply marking an ROI and setting the ROI trigger to only those events contributing to the ROI channels. To set the ROI trigger, place the spectrum cursor within an ROI and press the ROI trigger button. If the ROI trigger button is depressed and pressed again, the ROI boundaries displayed in the Trace Viewer will be updated to the boundaries of the ROI that the spectrum cursor is placed in.

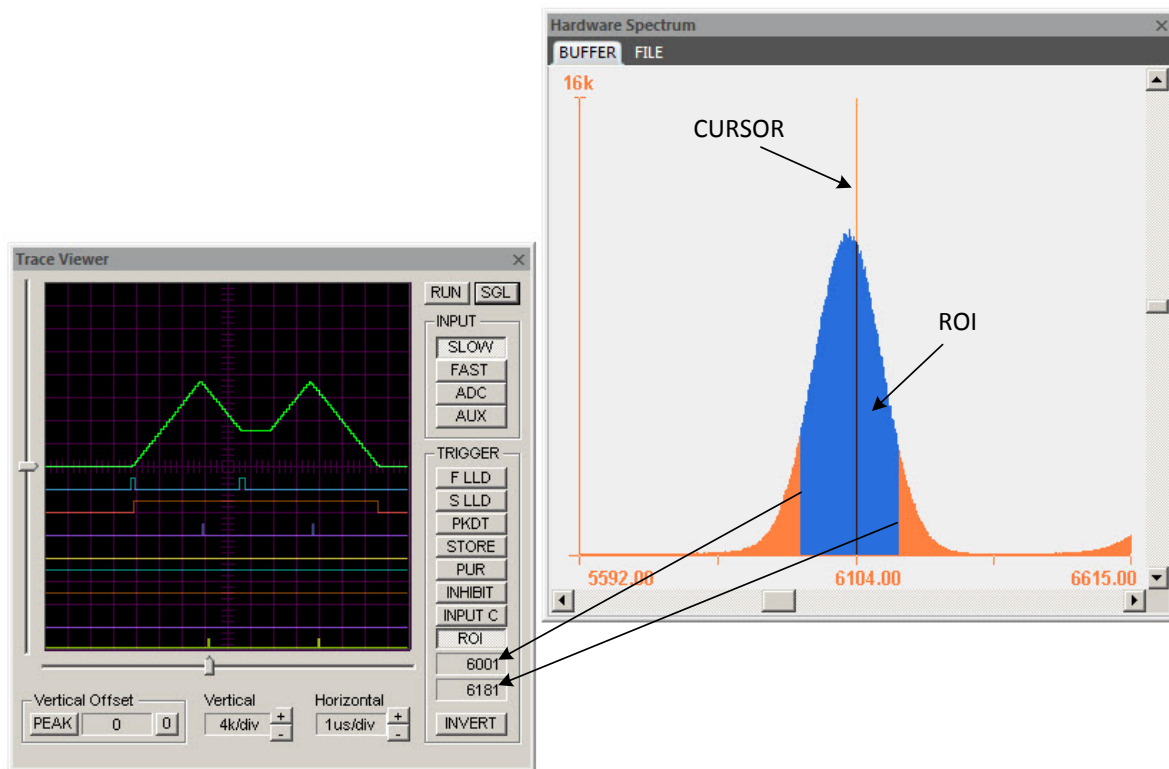


Figure 3.2.23. Setting the ROI trigger

The **Trace Viewer** uses a pre-trigger acquisition to capture portions of the signals preceding the trigger. The trigger position can be adjusted by the slider **TRIGGER POSITION**. This allows a larger or smaller portion of the pre-trigger signal to be captured and displayed.

The **PEAK** button and the associated function are unique to the labZY Trace Viewer. When this button is depressed, each digital signal waveform is automatically zero-referenced to its peak. This allows detailed investigation of the peaks of the signals, as the vertical scale can be set to small values without losing the ability to observe the peaks of the digital signal. The PEAK mode and the ROI or PKDT triggers allow for fine adjustment of the **LONG TC** by observing the flat top of the digital signal at the highest possible vertical resolution.

Debug Window

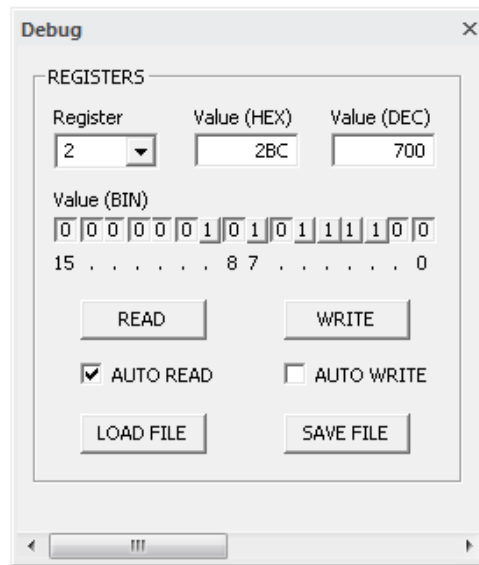


Figure 3.2.24. Debug Window.

The [Debug Window](#) has the direct controls of the FPGA internal registers and can be used as a custom design debug device. When the [AUTO READ](#) is selected, the registers will be updated automatically.

Events Window

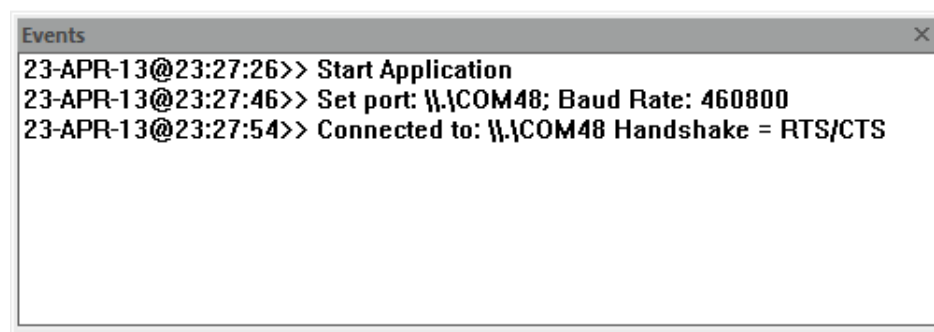


Figure 3.2.25. Events Window.

Various system level events are displayed in the [Events Window](#).






Device Bars

Standard



Figure 3.3.1. Standard device bar.

Button function from left to right:

-  Information about labZY-TDCR software.
-  Open file.
-  Save spectrum as...
-  Restore Layout.
-  Default Layout.

Hardware Control



Figure 3.3.2. Hardware not connected.










Figure 3.3.3. Hardware connected. Spectrum acquisition stopped.



Figure 3.3.4. Hardware connected. Spectrum acquisition in progress.

Button function from left to right:











-  Automatic search for ports and automatic connection.
-  Manually select port.
-  Connect to hardware.
-  Disconnect from hardware.
-  Erase spectrum and reset timers = RESET.
-  Start spectrum acquisition = START.
-  Stop spectrum acquisition = STOP.

View Control



Figure 3.3.5. Viewer Control device bar.

Button function from left to right:

-  Linear vertical scale.
-  Logarithmic vertical scale.
-  Automatic vertical scale.
-  Expand vertically.
-  Condense vertically.
-  Expand horizontally around the cursor.
-  Condense horizontally around the cursor.
-  Expand horizontally from the left spectrum view border.
-  Condense horizontally towards the left spectrum view border.
-  Display the full spectrum.

Mouse and Keyboard Functions

The Mouse and the Keyboard are used to navigate and operate the windows and their controls. In the [Buffer](#) and [File Windows](#), the mouse and the keyboard are used to move the spectrum cursor, to mark or unmark regions of interest (ROI), and to adjust the spectrum view. Use the SPACE BAR to toggle the spectrum display between: a filled histogram (default), dots, a step function, and a line.

Selecting and Moving the Cursor

To select the cursor, first click the right or left mouse button anywhere within the [Buffer Window](#) or the [File Window](#). The cursor will be positioned at the point of the mouse click. To move the cursor, press and hold either the left button or the right button of the

mouse. Alternatively, the cursor may be moved left or right by pressing the LEFT ARROW KEY or the RIGHT ARROW KEY of the keyboard respectively.

Marking/Unmarking ROI

To mark an ROI, use the sequence shown below, or press SHIFT+LEFT ARROW KEY or SHIFT+RIGHT ARROW KEY respectively.

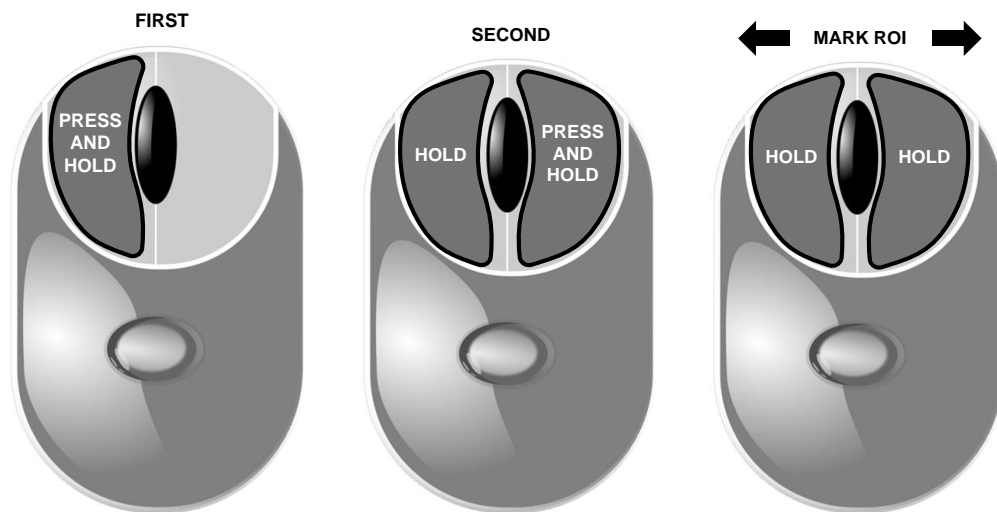


Figure 3.4.1. How to mark an ROI using the mouse.

To unmark an ROI, use the sequence shown below, or press CTRL+LEFT ARROW KEY or CTRL+RIGHT ARROW KEY respectively.

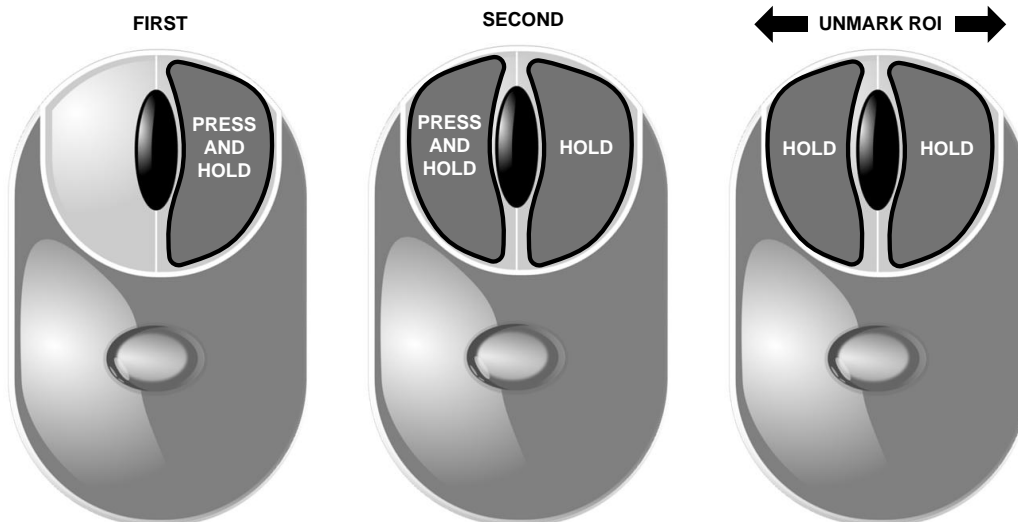


Figure 3.4.2. How to unmark an ROI using the mouse.

Controlling the Spectrum Display

The mouse can be used to control the number of spectrum channels displayed within the [Buffer Window](#) or the [File Window](#). A double click of the LEFT mouse button reduces the number of channels shown within the window - expanding horizontally. A double click of the RIGHT mouse button increases the number of channels shown within the window - condensing horizontally. The mouse horizontal control functions are shown below.

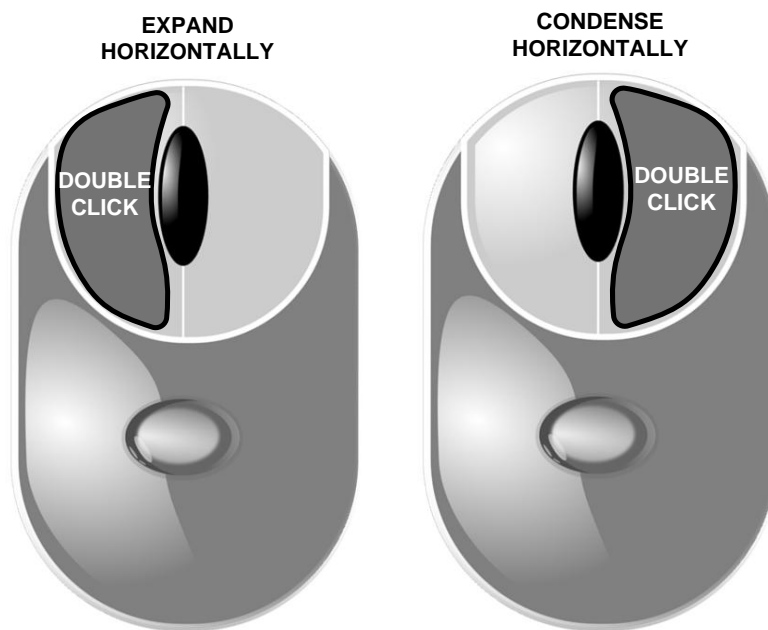


Figure 3.4.3. How to expand and condense the spectrum display horizontally.

The "I" KEY and the "O" KEY can also be used to expand and condense the spectrum display horizontally. The section of the spectrum displayed in the [Buffer Window](#) or the [File Window](#) can be selected by sliding the bar of the horizontal slider or by "bumping" the cursor to the left or the right borders of the spectrum display window.

The mouse and the keyboard can also be used to control the spectrum display vertically. The vertical control of the spectrum display determines the number of counts displayed within the vertical boundaries of the [Buffer Window](#) or the [File Buffer](#). The vertical scale is controlled by the MOUSE WHEEL, the UP ARROW KEY of the keyboard, the DOWN ARROW KEY of the keyboard, or the vertical sliding bar. The MOUSE WHEEL function is illustrated below.

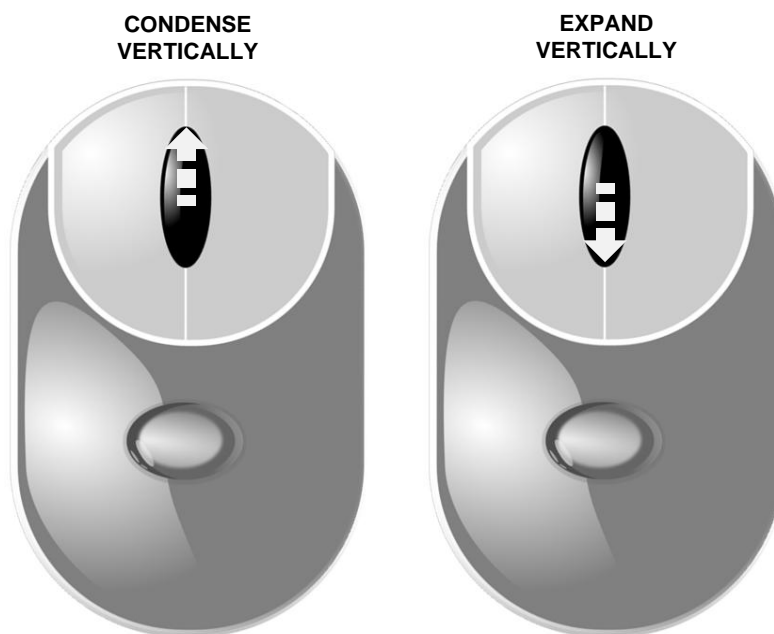


Figure 3.4.4. How to expand and condense vertically the spectrum display.

Appendix A: TDCR File Formats (.tdc and .csv)

.tdc file

There are three major section in the TDCR file. The header of the sections are shown in bold italic. Each line in the TDCR record has two entries separated by coma. The first entry is a description of a variable and the second is the value of the variable. For the section entries the first entry is the section name and the second entry is the name of a subsection. Below is an example **.tdc** file

nanoTDCR, Hardware

Serial Number,10009
Firmware Version,50.20
FPGA Version, 6.4

Measurement, Settings

Measurement Tag,TDCR Measurement
Operator, VJ
Nuclides, Am-241
LS Cocktail, LSMargarita
High Voltage, +1000V
Threshold A [mV], -5.200
Threshold B [mV], -4.000
Threshold C [mV], -5.200
Dead Time Extension 1 [us], 50.000
Dead Time Extension 2 [us], 50.000
Coincidence Window N [ns],40
Coincidence Window M [ns],40
Preset Sequential Runs,10
Preset Time per Run [s], 60.000
Time Gap between Runs [s], 8.000
Stop Timer,REAL

Measurement, Data

Runs Completed, 10

Run1: START TIME: SYSTEM,08/10/2018 13:16:07.548

Run1: Real Time [s], 60.000

Run1: Live Time PMT A E1 [s], 52.198

Run1: Live Time PMT A E2 [s], 52.198

Run1: Live Time PMT B E1 [s], 51.672

Run1: Live Time PMT B E2 [s], 51.672

Run1: Live Time PMT C E1 [s], 51.802

Run1: Live Time PMT C E2 [s], 51.802

Run1: PMT A Raw [counts], 1894126

Run1: PMT A Raw [cps], 31568.767

Run1: PMT B Raw [counts], 2272229

Run1: PMT B Raw [cps], 37870.483

Run1: PMT C Raw [counts], 3405566

Run1: PMT C Raw [cps], 56759.433

Run1: PMT A Ext1 [counts], 141532

Run1: PMT A Ext1 [cps], 2711.445

Run1: PMT B Ext1 [counts], 149733

Run1: PMT B Ext1 [cps], 2897.759

Run1: PMT C Ext1 [counts], 145150

Run1: PMT C Ext1 [cps], 2802.015

Run1: PMT A Ext2 [counts], 141532

Run1: PMT A Ext2 [cps], 2711.445

Run1: PMT B Ext2 [counts], 149733

Run1: PMT B Ext2 [cps], 2897.759

Run1: PMT C Ext2 [counts], 145150

Run1: PMT C Ext2 [cps], 2802.015

Run1: Live Time AB Ext1 [s], 50.238

Run1: Live Time BC Ext1 [s], 50.238

Run1: Live Time AC Ext1 [s], 50.238

Run1: Live Time T Ext1 [s], 50.238

Run1: Coincidence AB_N1 [counts], 125864

Run1: Coincidence AB_N1 [cps], 2505.355

Run1: Coincidence BC_N1 [counts], 125875

Run1: Coincidence BC_N1 [cps], 2505.573

Run1: Coincidence AC_N1 [counts], 125871

Run1: Coincidence AC_N1 [cps], 2505.494

Run1: Coincidence D_N1 [counts], 126040

Run1: Coincidence D_N1 [cps], 2508.858

Run1: Coincidence T_N1 [counts], 125785

Run1: Coincidence T_N1 [cps], 2503.782

Run1: Coincidence AB_M1 [counts], 125864

Run1: Coincidence AB_M1 [cps], 2505.355

Run1: Coincidence BC_M1 [counts], 125875

Run1: Coincidence BC_M1 [cps], 2505.573

Run1: Coincidence AC_M1 [counts], 125871

Run1: Coincidence AC_M1 [cps], 2505.494

Run1: Coincidence D_M1 [counts], 126040

Run1: Coincidence D_M1 [cps], 2508.858

Run1: Coincidence T_M1 [counts], 125785
Run1: Coincidence T_M1 [cps], 2503.782

Run1: Live Time AB Ext2 [s], 51.107
Run1: Live Time BC Ext2 [s], 50.766
Run1: Live Time AC Ext2 [s], 51.255
Run1: Live Time T Ext2 [s], 50.238

Run1: Coincidence AB_N2 [counts], 128038
Run1: Coincidence AB_N2 [cps], 2505.293
Run1: Coincidence BC_N2 [counts], 127175
Run1: Coincidence BC_N2 [cps], 2505.122
Run1: Coincidence AC_N2 [counts], 128399
Run1: Coincidence AC_N2 [cps], 2505.102
Run1: Coincidence D_N2 [counts], 132042
Run1: Coincidence D_N2 [cps], 2507.952
Run1: Coincidence T_N2 [counts], 125785
Run1: Coincidence T_N2 [cps], 2503.782

Run1: Coincidence AB_M2 [counts], 128038
Run1: Coincidence AB_M2 [cps], 2505.293
Run1: Coincidence BC_M2 [counts], 127175
Run1: Coincidence BC_M2 [cps], 2505.122
Run1: Coincidence AC_M2 [counts], 128399
Run1: Coincidence AC_M2 [cps], 2505.102
Run1: Coincidence D_M2 [counts], 132042
Run1: Coincidence D_M2 [cps], 2507.952
Run1: Coincidence T_M2 [counts], 125785
Run1: Coincidence T_M2 [cps], 2503.782

Run2: START TIME: SYSTEM,08/10/2018 13:15:17.548

Run2: Real Time [s], 60.000
Run2: Live Time PMT A E1 [s], 52.198
Run2: Live Time PMT A E2 [s], 52.198
Run2: Live Time PMT B E1 [s], 51.672
Run2: Live Time PMT B E2 [s], 51.672
Run2: Live Time PMT C E1 [s], 51.802
Run2: Live Time PMT C E2 [s], 51.802
Run2: -----

-
-
-

Run10: -----

Run110: Coincidence T_M2 [counts], 125772
Run10: Coincidence T_M2 [cps], 2503.748

.csv file

The .csv file records provide a condensed but sufficient information for completing an activity assesment using the TDCR method. The text in *italic* represents a single line in the **.tdc** file. The data from each measurement run is entered in a single row.

TDCR Measurement

Date [dd/mm/yyyy], SYSTEM,08/10/2018

Time [hh-mm-ss.ms], SYSTEM,13-16-07.548

Hardware, nanoTDCR

Serial Number,10009

Firmware Version,50.20

FPGA Version, 6.3

Operator, PC

Nuclides, Am-241

LS Coctail, LSParis

High Voltage, +1100V

Threshold A [mV], -5.200

Threshold B [mV], -4.000

Threshold C [mV], -5.200

Dead Time Extension 1 [us], 50.000

Dead Time Extension 2 [us], 50.000

Coincidence Window N [ns],40

Coincidence Window M [ns],40

Preset Sequential Runs,1

Preset Time per Run [s], 60.000

Time Gap between Runs [s], 1.000

Stop Timer,REAL

Runs Completed, 3

Run,Start Offset [s],RealTime[s],AB-N1[cps],BC-N1[cps],AC-N1[cps],D-N1[cps],T-N1[cps],AB-M1[cps],BC-M1[cps],AC-M1[cps],D-M1[cps],T-M1[cps],AB-N2[cps],BC-N2[cps],AC-N2[cps],D-N2[cps],T-N2[cps],AB-M2[cps],BC-M2[cps],AC-M2[cps],D-M2[cps],T-M2[cps]

1,0.000000, 60.000, 2505.355, 2505.573, 2505.494, 2508.858, 2503.782, 2505.355, 2505.573, 2505.494, 2508.858, 2503.782, 2505.293, 2505.122, 2505.102, 2507.952, 2503.782, 2505.293, 2505.122, 2505.102, 2507.952, 2503.782,

2, 61.000000, 60.000, 2505.355, 2505.573, 2505.494, 2508.858, 2503.782, 2505.355, 2505.573, 2505.494, 2508.858, 2503.782, 2505.293, 2505.122, 2505.102, 2507.952, 2503.782, 2505.293, 2505.122, 2505.102, 2507.952, 2503.782,

3, 122.000000, 60.000, 2505.355, 2505.573, 2505.494, 2508.858, 2503.782, 2505.355, 2505.573, 2505.494, 2508.858, 2503.782, 2505.293, 2505.122, 2505.102, 2507.952, 2503.782, 2505.293, 2505.122, 2505.102, 2507.952, 2503.782,

Appendix B: labZY MCA File Format (.Its)

```
<?xml version="1.0"?>
<nanoTDCR>
  <serialnumber>10001</serialnumber>
  <spectrum>
    <tag>labZY-TDCR Input A Spectrum</tag>
    <hardsize>4096</hardsize>
    <softsize>4096</softsize>
    <offset>4096</offset>
    <data>
      0
      0
      0
      12
      17
      82
      44
      .
      .
      .
      346
      +567
      +1054
      +1109
      +985
      +605
      588
      561
      500
      389
      .
      .
      .
      .
      +0
      +5
      2
      1
    </data>
  </spectrum>
  <time>
    <real> 100.0000</real>
    <live> 99.9780</live>
    <dead> 0.0220</dead>
    <date>11/12/2018 01:45:06</date>
  </time>
</nanoTDCR>
```

Hardware

Tag caption and spectrum size information. For Input A,B,C the offset is 4096, for Input E the offset is 0.

Channel counts from Channel 0 to Channel 4095. An explicit + sign in front of the channel counts indicates that the corresponding channel is marked as an ROI.

Time and date information.

<pre> <registers> <size>128</size> <data> 0 8000 10 1 2 1 35 118 37 529 . . . 1 0 0 </data> </registers> <calibration> <enabled>YES</enabled> <units>2</units> <channelA> 0.0000</channelA> <energyA> 0.0000</energyA> <useA>0</useA> <channelB> 453.0000</channelB> <energyB> 470.0000</energyB> <useB>1</useB> <channelC> 1289.0000</channelC> <energyC> 1700.0000</energyC> <useC>1</useC> <useall>YES</useall> </calibration> <volatile> <firmware>50.20</firmware> <intemp>35</intemp> <slowadc> 0.83</slowadc> </volatile> </nanoTDCR> </pre>		<p>Hardware Register record Register 0 to Register 127.</p> <p>Calibration data</p> <p>Volatile Data</p>
---	--	---

Appendix C: Setting BDC

To set the BDC follow these steps:

- 1) Use $BDC = 1$ to setup a measurement, all measurement parameters must be set
- 2) Acquire a spectrum at 16384 channel soft size and adjust the gain so that there are well above the half of the full spectrum size (16384) (Fig B1).
- 3) Mark an ROI that overlaps the middle of the spectrum (channel 8192).
- 4) Place the cursor within the ROI and press the ROI-SCA trigger button of the Trace Viewer.

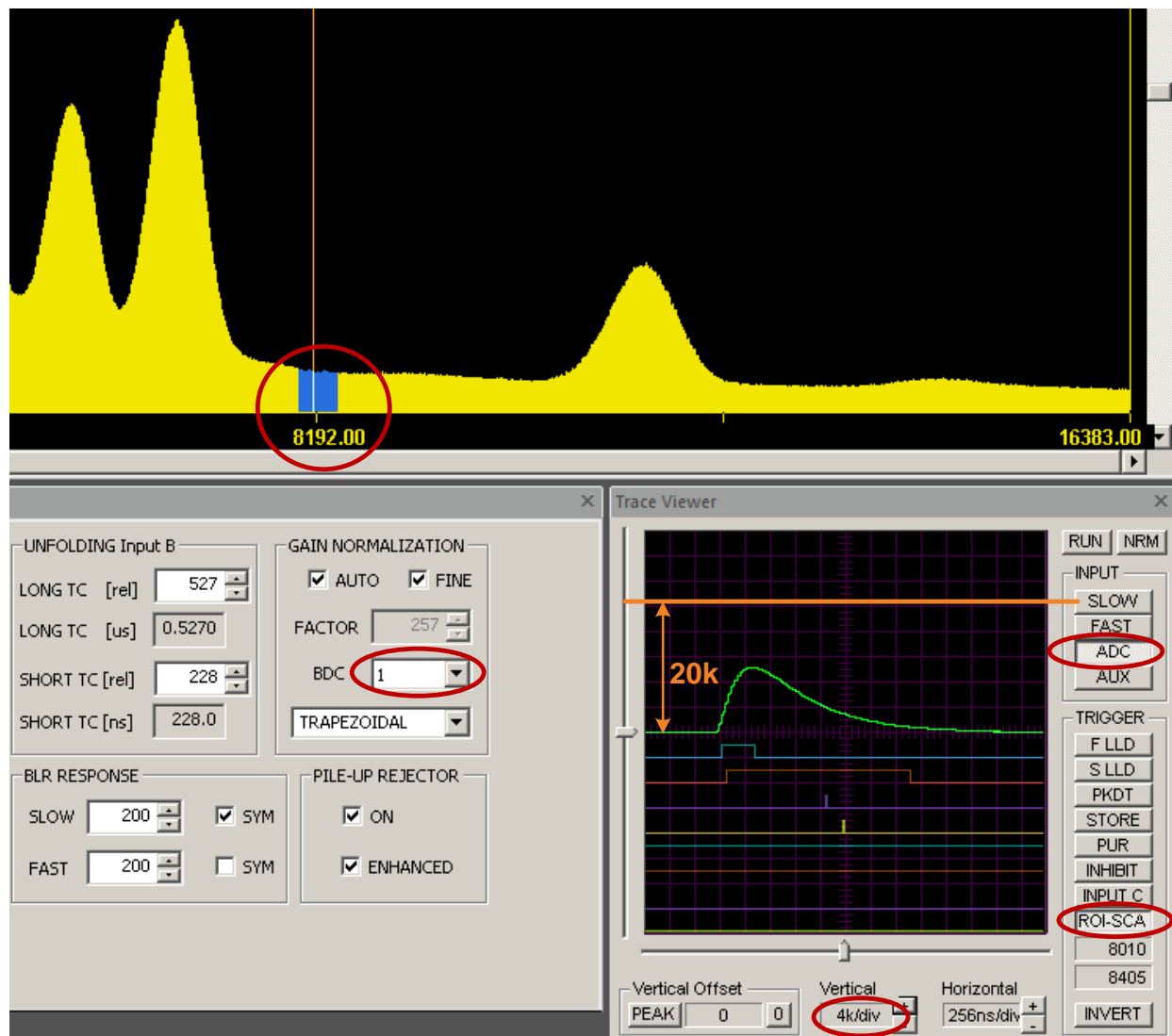


Figure B1. Example BDC that is not optimally adjusted.

- 5) Press/select the following buttons of the Trace Viewer: ADC, 0, RUN.
- 6) Set Trace Viewer Vertical to 4k/div, place the trigger mark at the middle of the window, and adjust Horizontal so that the peak of the ADC signal is well visible.
- 7) Adjust BDC so that the ADC peak amplitude is about 20k. This completes the adjustment.

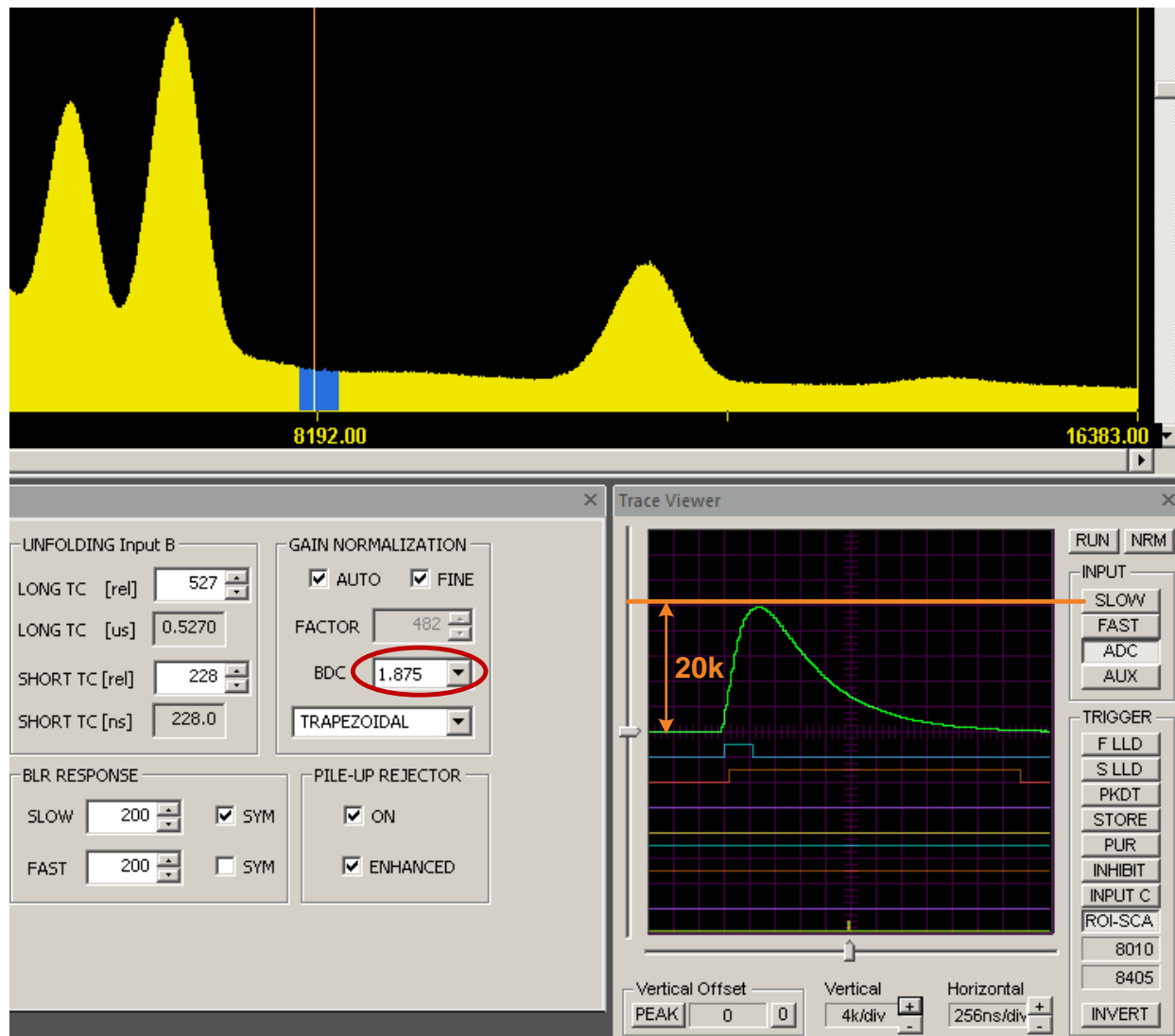


Figure B2. Example optimally adjusted BDC.