Software User Manual

labZY-TDCR

Versions 6.40 to 6.49

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 loses.

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

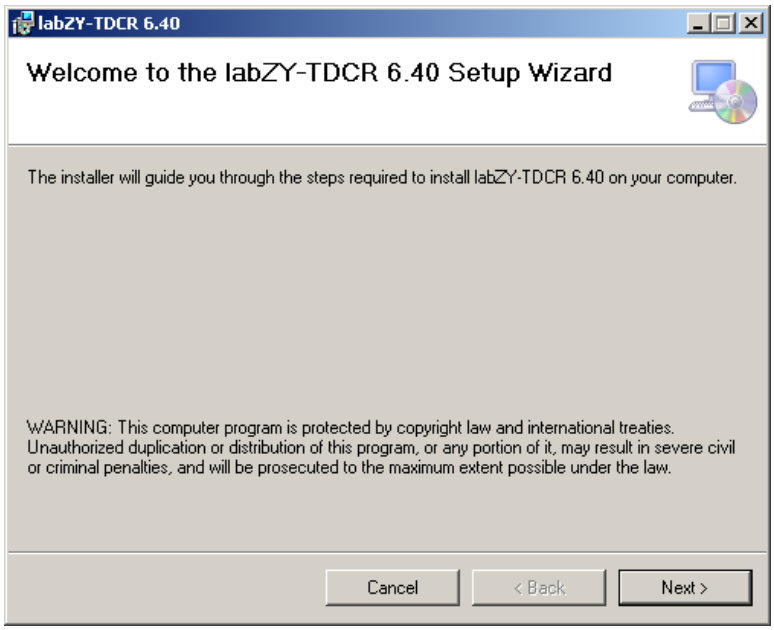


Figure 1.1. Welcome page of labZY-TDCR Setup Wizard window.

Press "Next."

Step 2

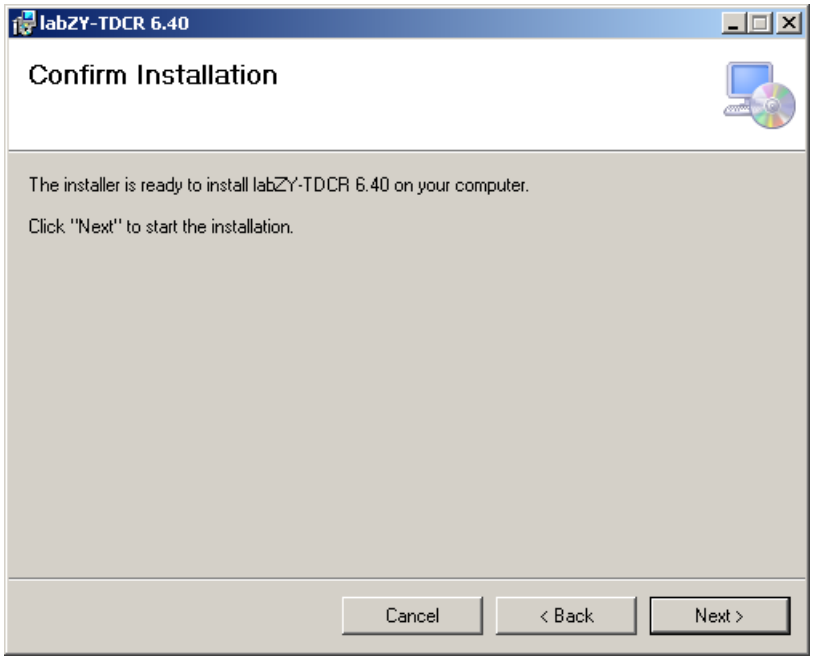


Figure 1.2 Confirm Installation page of labZY-TDCR Setup Wizard window.

Press “Next.”

Step 3

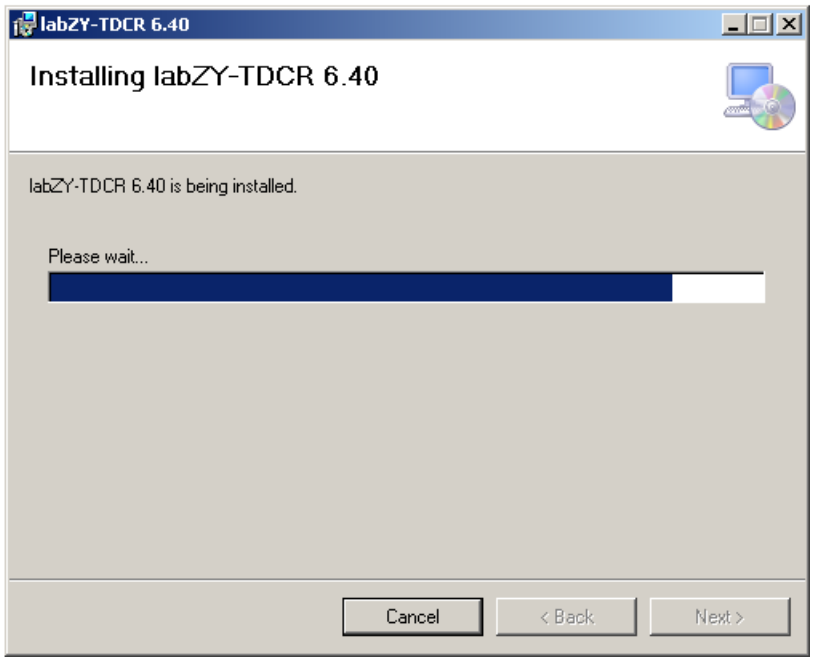


Figure 1.3. Wait for the installation to complete

Step 4

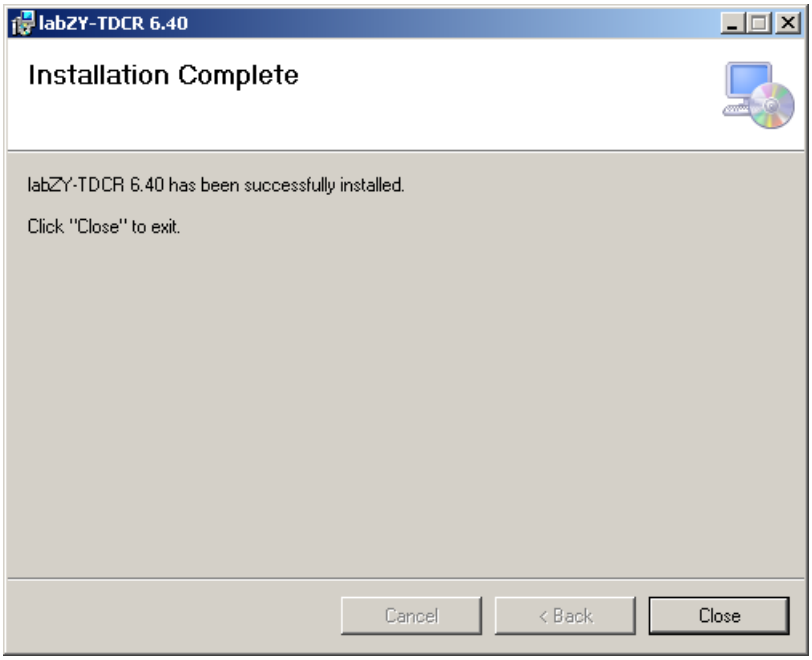


Figure 1.4. Installation Complete page of labZY-TDCR Setup Wizard window.

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.

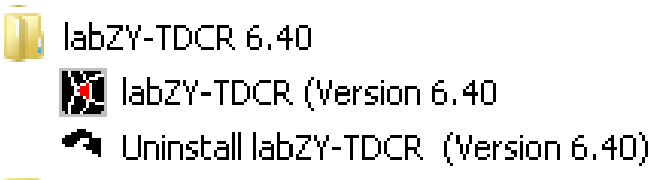


Figure 1.6. labZY group in Windows 7 and Windows XP.

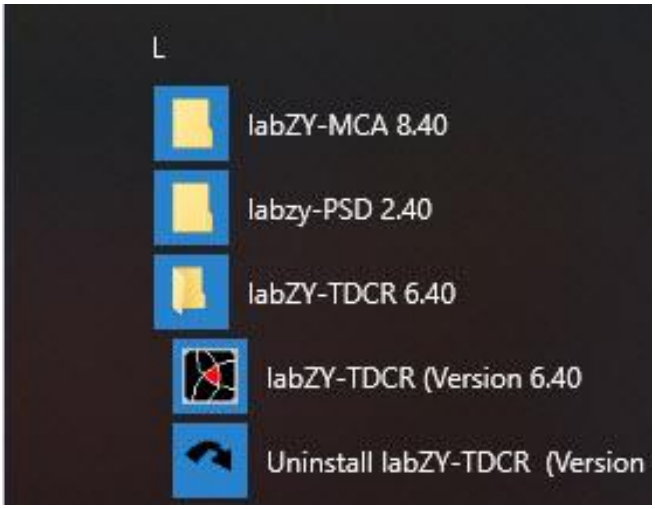


Figure 1.7. labZY group in Windows 10.

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

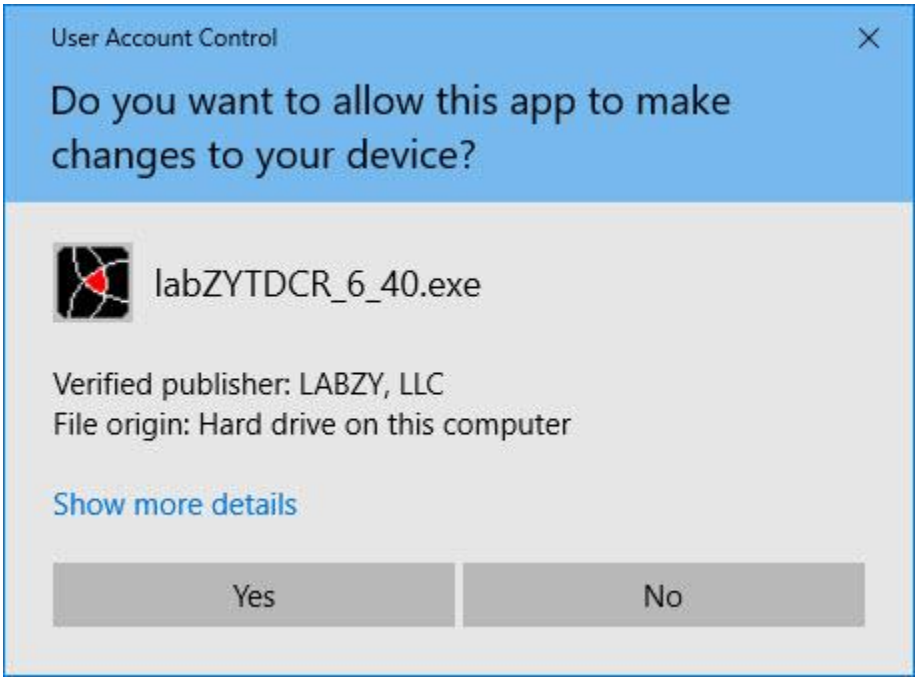


Figure 1.8. User Account Control - Verified Publisher: LABZY, LLC message.

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.

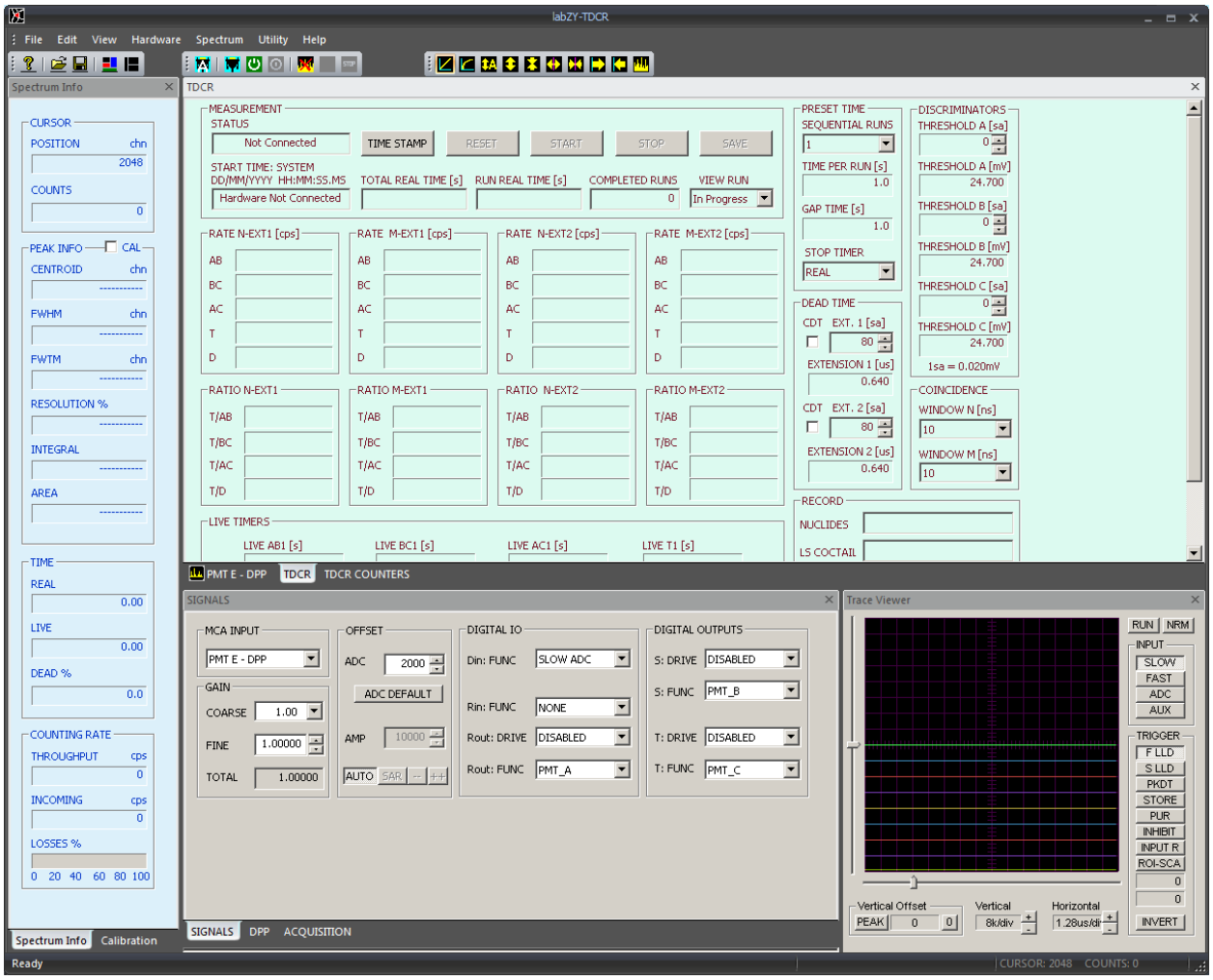


Figure 1.9. labZY-TDCR default layout.

TDCR Components

TDCR Window

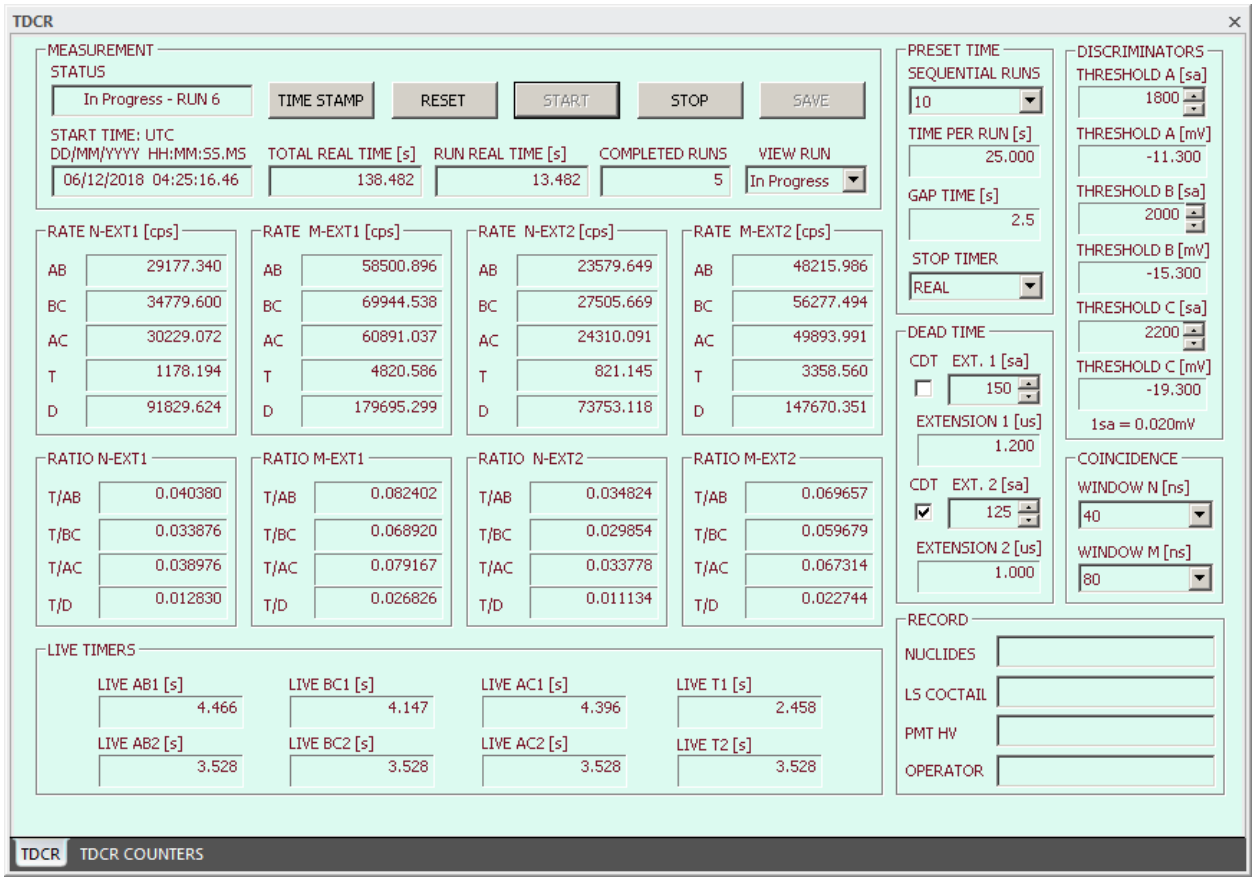


Figure 2.1. TDCR Window.

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.

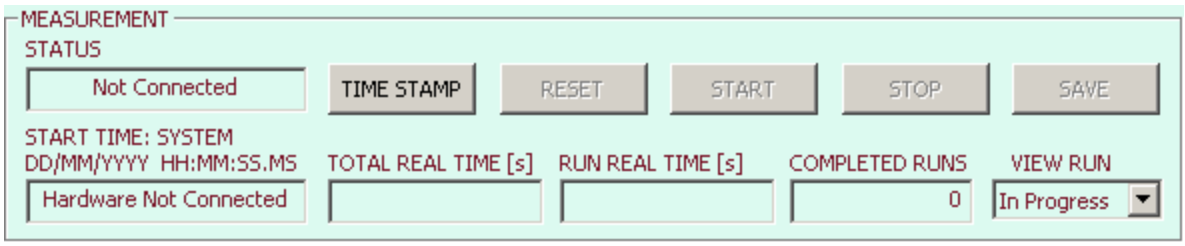


Figure 2.2. The MEASUREMENT control group.

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 fro 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 stemp 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 inacurate 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.

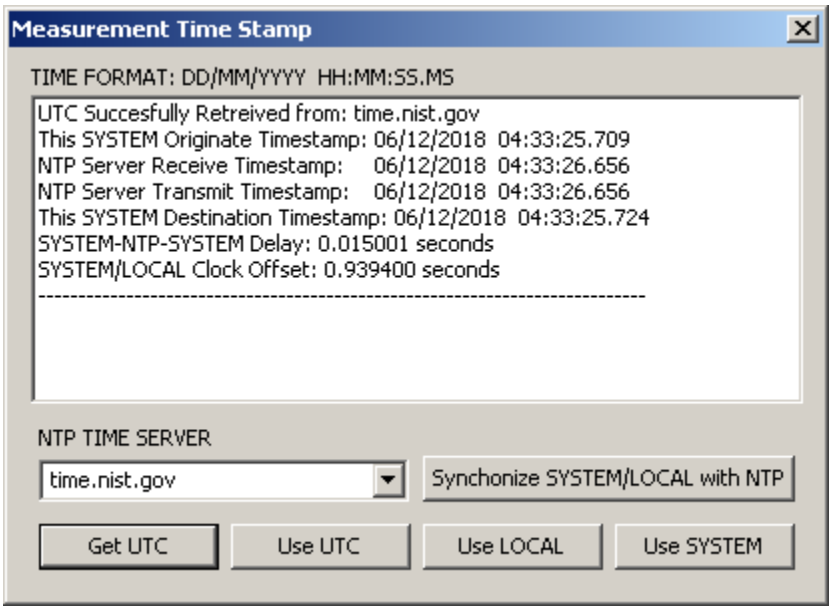


Figure 2.3. Time Stamp Dialog.

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.

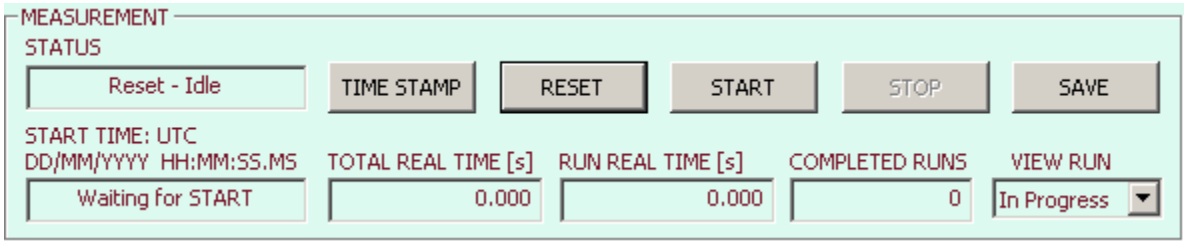


Figure 2.4. **Idle** Status - Ready to START TDCR counting.

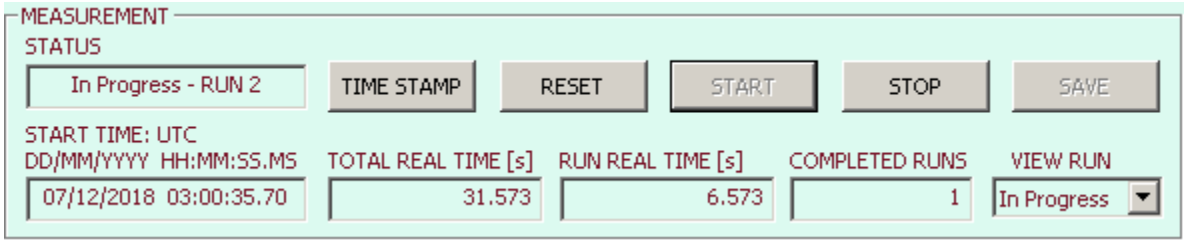


Figure 2.5. **In Progress-RUN #** Status - Ready to START TDCR counting.

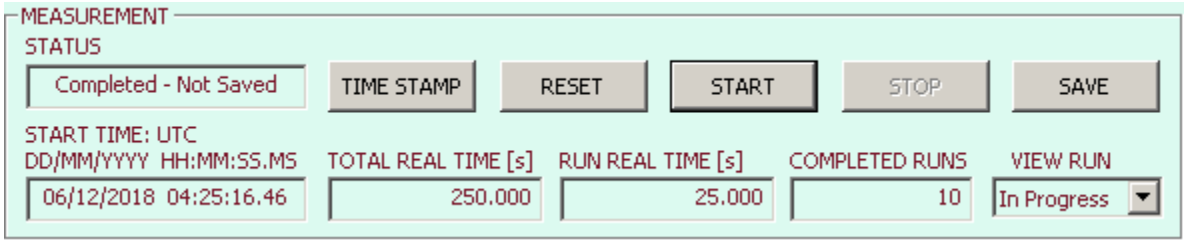


Figure 2.6. **Completed- Not Saved** Status.

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 STAUS 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 attemt is made to reset the TDCR counters and timers while the completed or interrupted measurement is not saved the dialog in Fig. 2.7will 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.

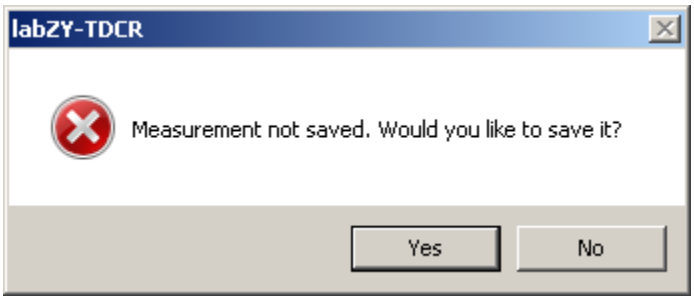


Figure 2.7. Dialog to prevent accidental loss of measurement data.

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...

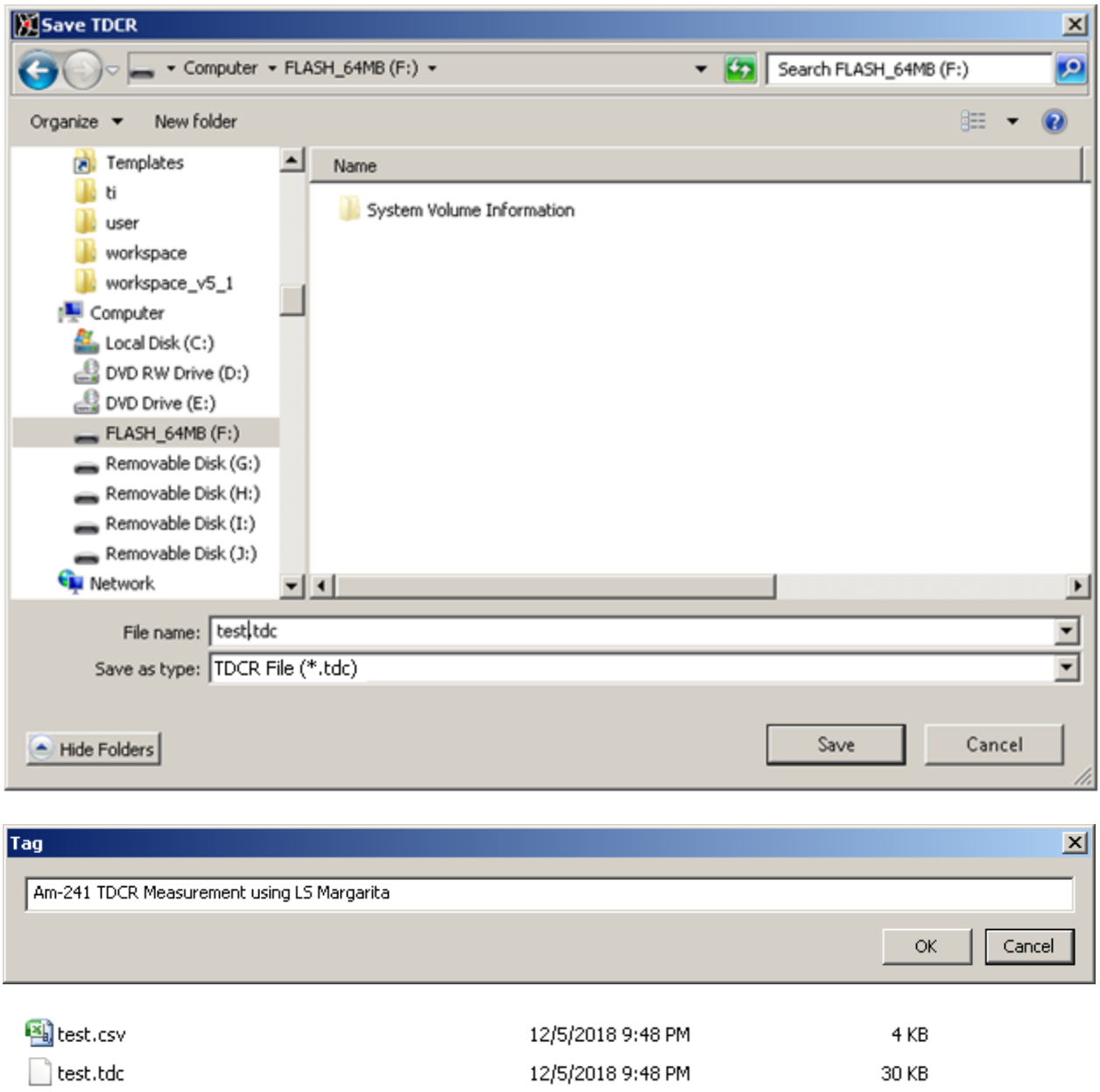


Figure 2.8. Saving the TDCR measurement.

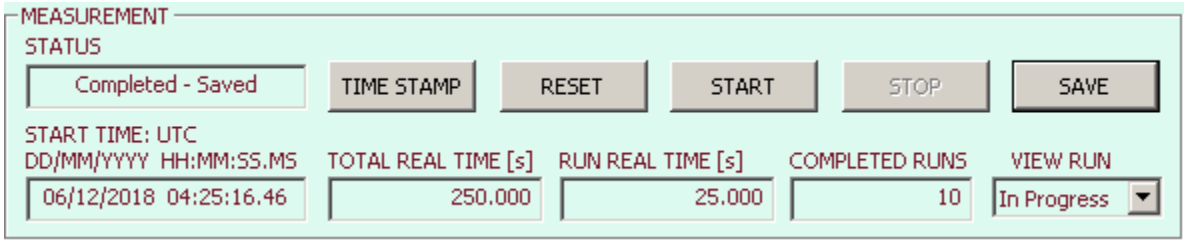


Figure 2.9. **Completed-Saved** Status.

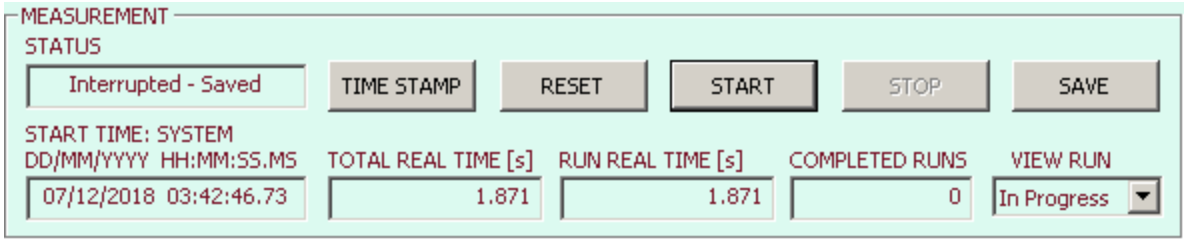


Figure 2.10. **Interrupted-Saved** Status.

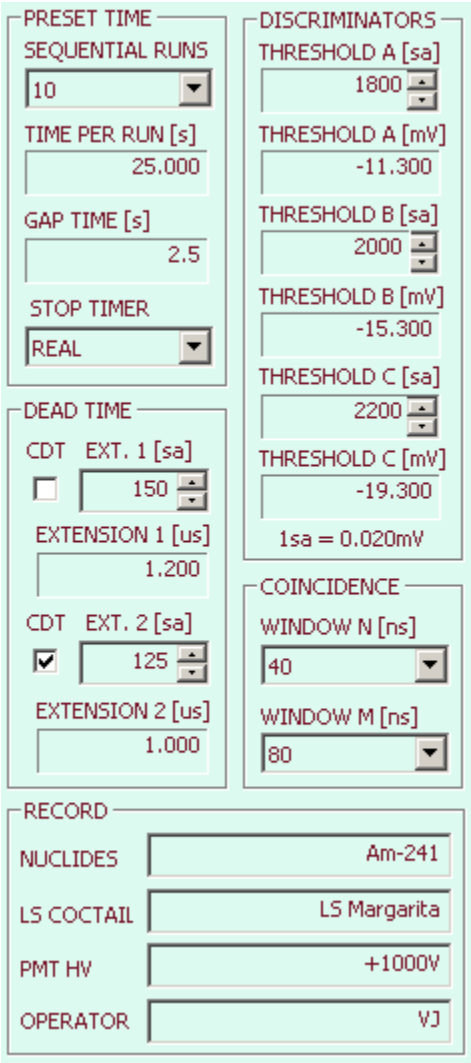


Figure 2.11. Hardware Controls.

The DISCRIMINATORS group contains the controls of the nanoTDCR discriminator thresholds. The adjustment of these thresholds is crytical 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. Typically the thresholds are set at few negative millivolts.

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. nanoTDCR has four sets of counters allowing parallel acquisition of four independent TDCR counters - combination of two dead time extensions and two coincidence windows. There is a check box CDT next to each dead time extension control. When this box is checked the TDCR counters will use the corresponding dead time extension as a common dead time (MAC3 mode). If the box is unchecked each PMT channel will have its own dead/live time - independent dead time IDT.

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. naoTDCR can perform sequential repeating TDCR measurements of up to 64 RUNS. The controls alow to specify the time per run and a gap time between the runs. The minimum gap time is 100 µs 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.

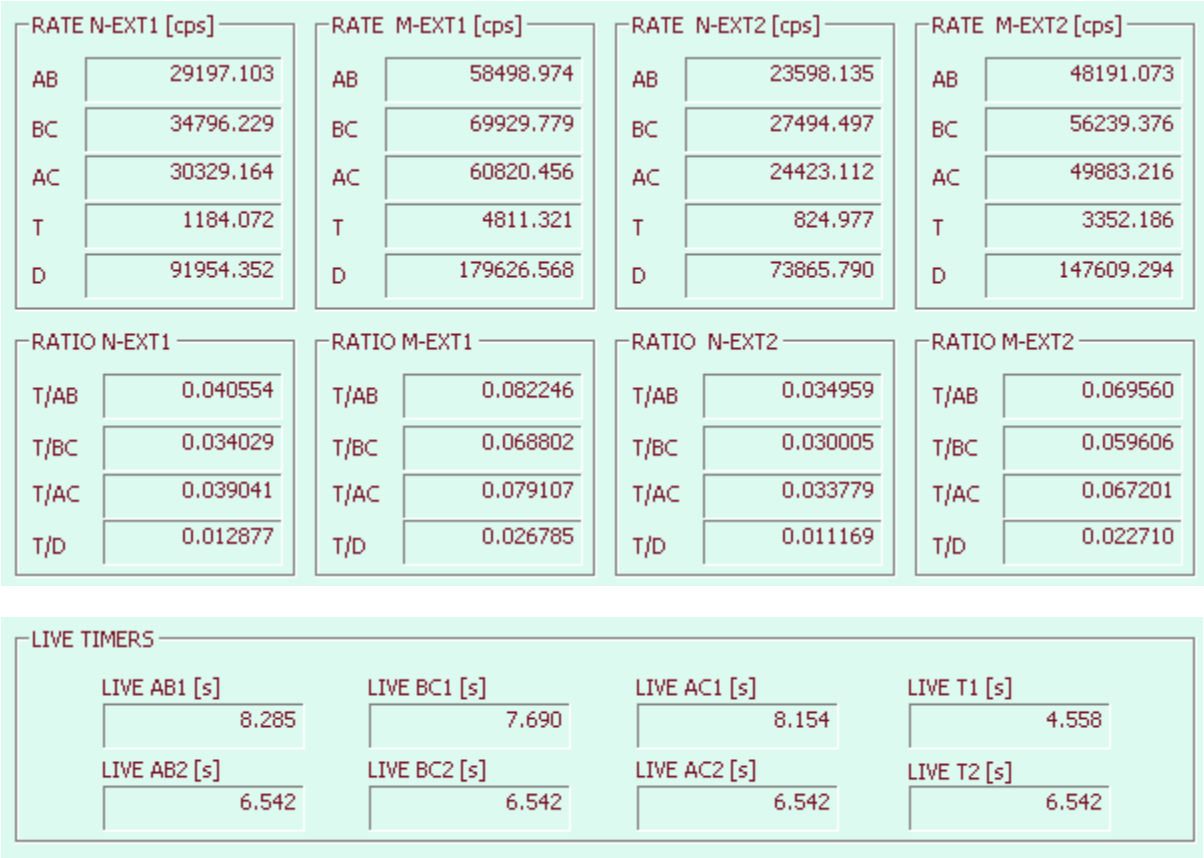


Figure 2.12. TDCR Measurement Information.

TDCR Counters Window

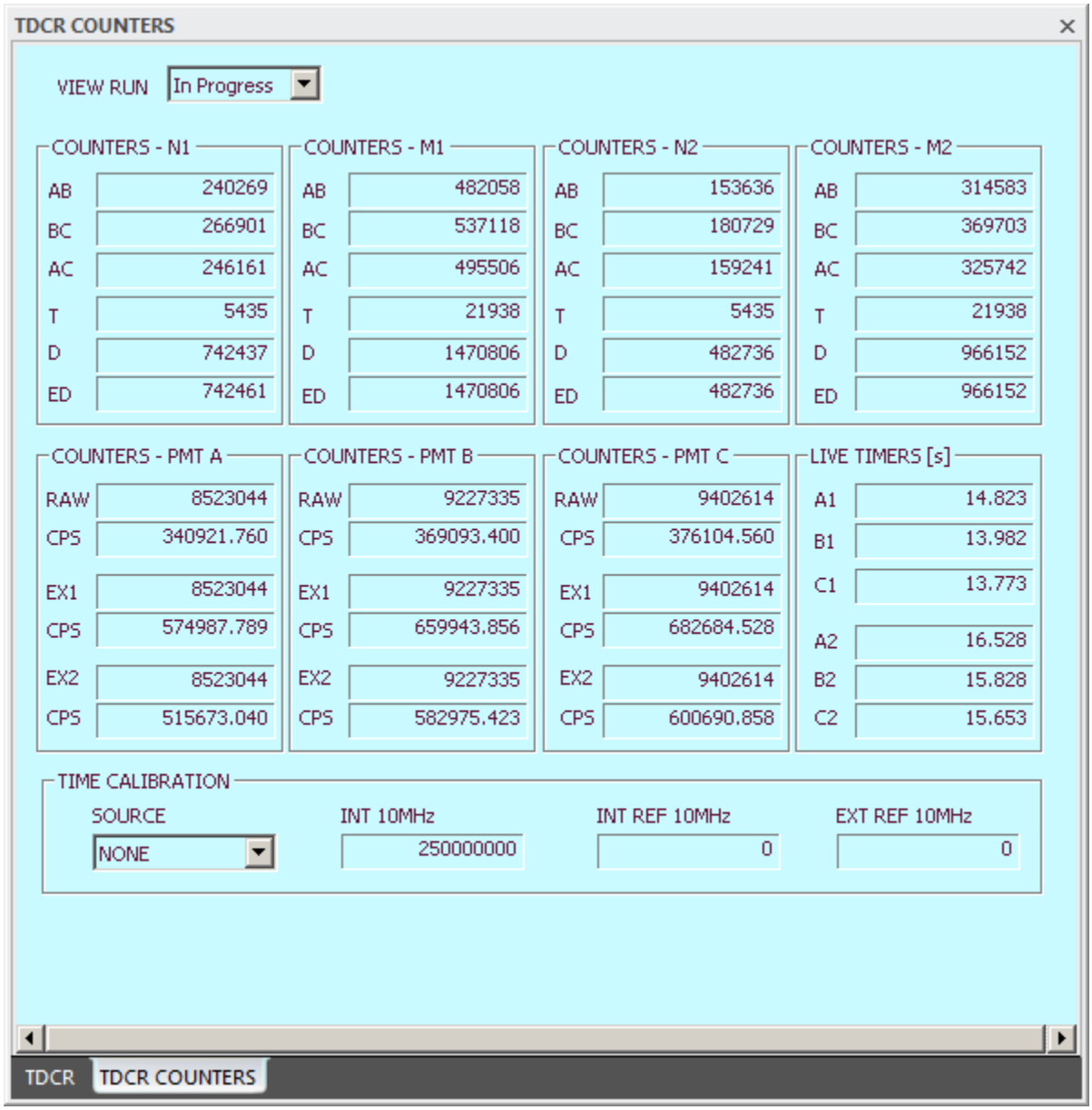


Figure 2.13. TDCR Counters Window.

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.

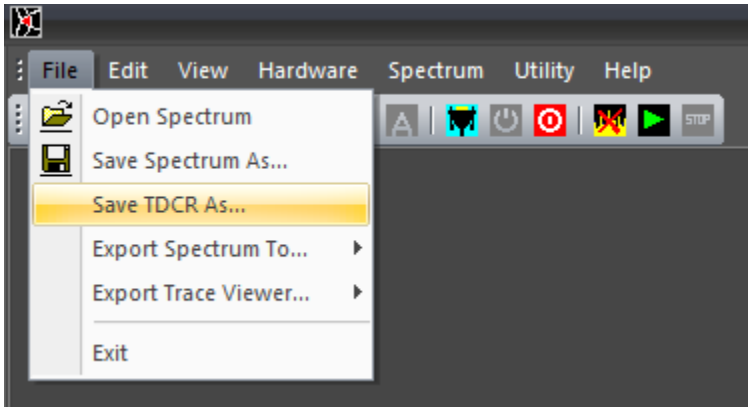


Figure 2.14. Save TDCR As... command.

MCA Components

Menu Components

File

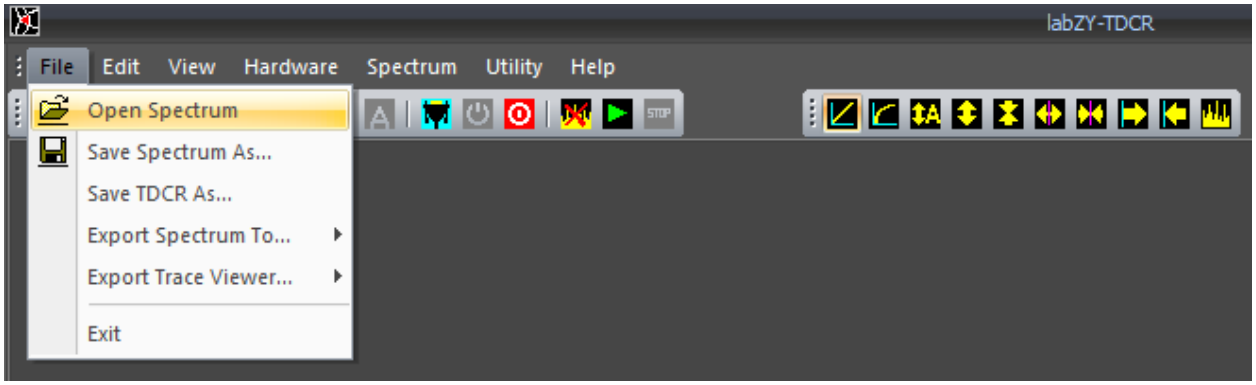


Figure 3.1.1. File menu.

The File menu can Open Spectrum files and Save Spectrum As… a labZY MCA file format, with default extension **.lts**. Additionally, it can Export Spectra to other file formats. The labZY MCA file format (**.lts**) 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 **.lts**. 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.

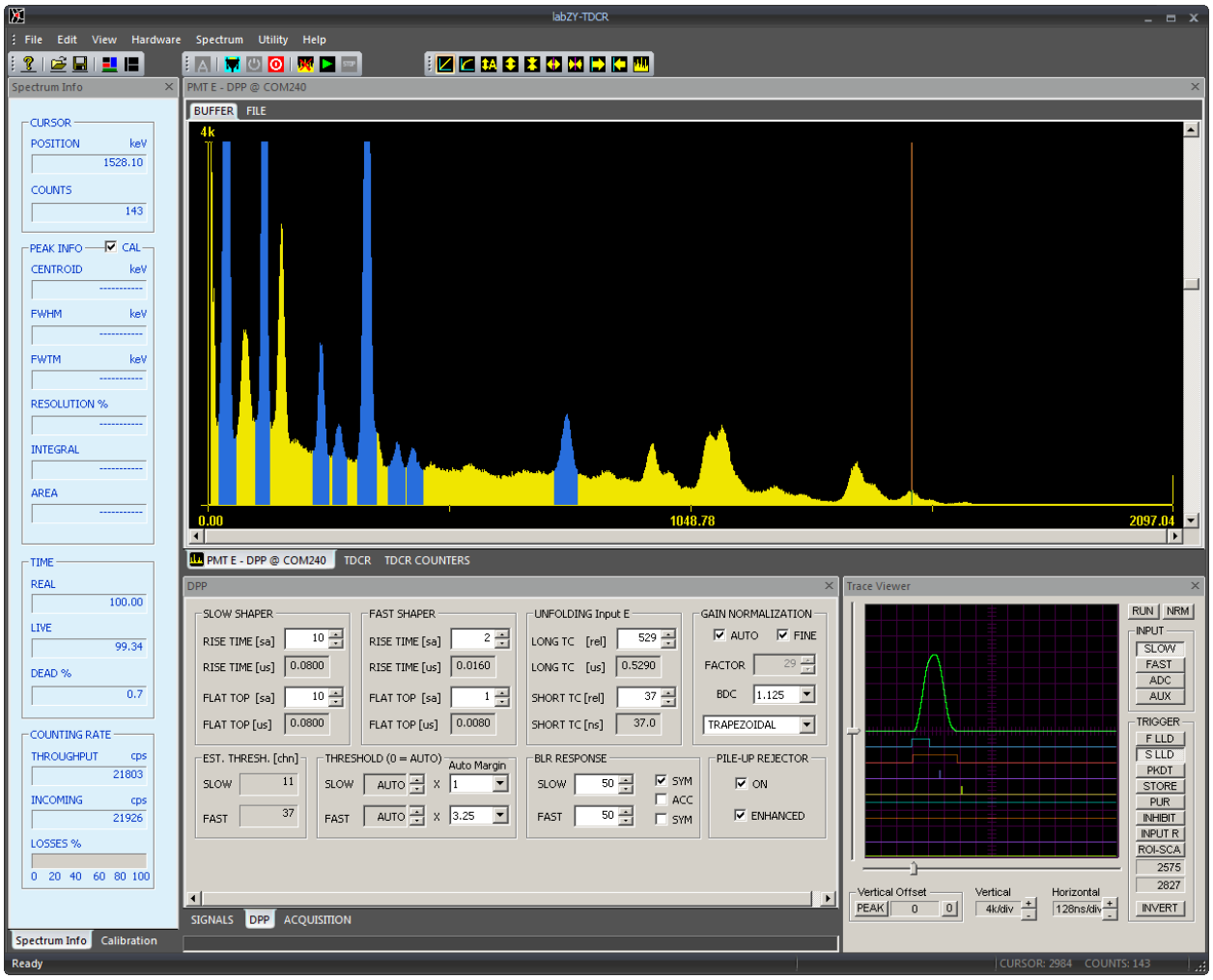


Figure 3.1.3. labZY-TDCR sample spectrum (Eu-152, LaBr detector, Input E) in default layout.

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.

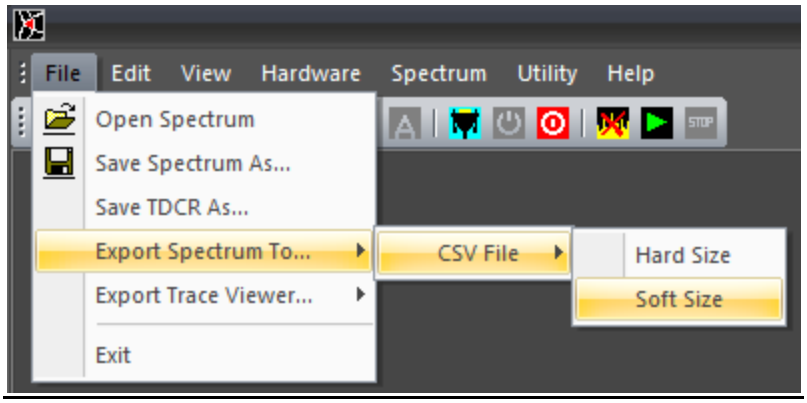


Figure 3.1.4. File menu → Export Spectrum To… → CSV File options.

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.

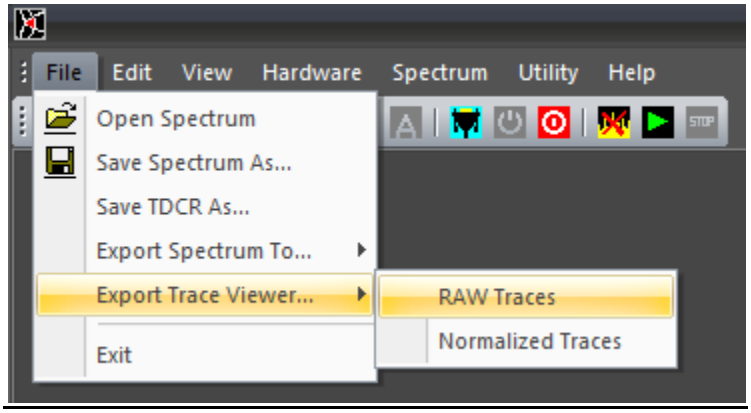


Figure 3.1.5. File menu → Export Trace Viewer… options.

Edit

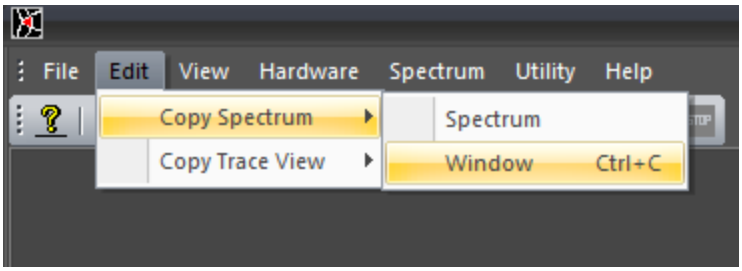
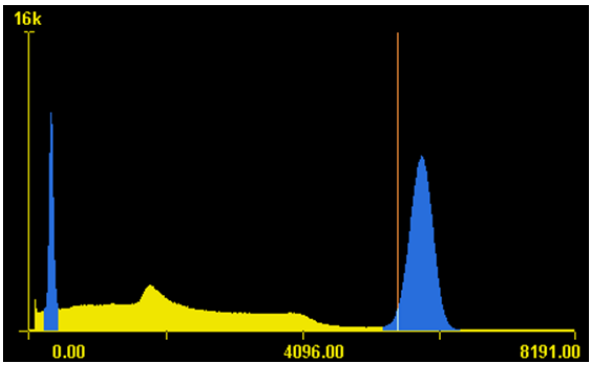
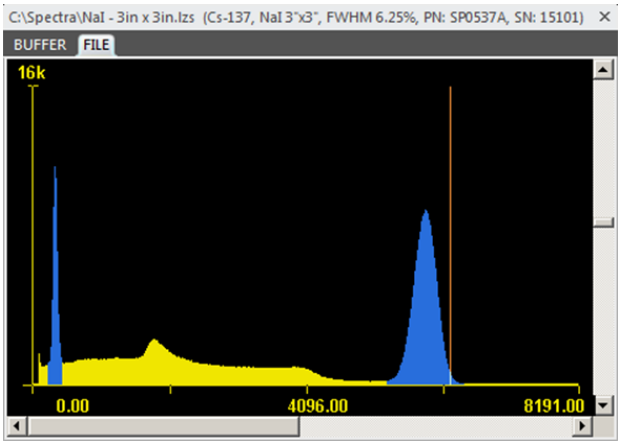


Figure 3.1.6. Edit menu → Copy Spectrum options.

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).

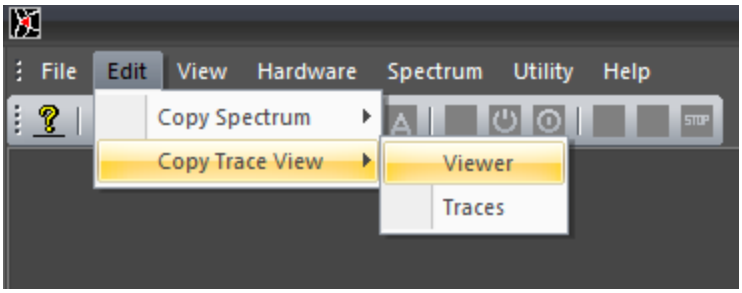
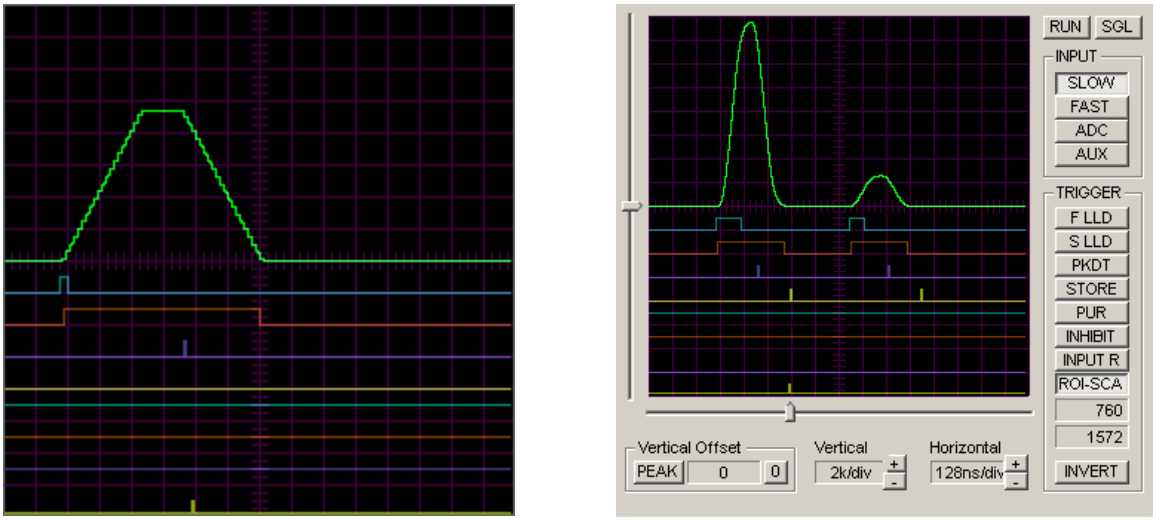


Figure 3.1.8. Edit menu → Copy Trace View options.

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

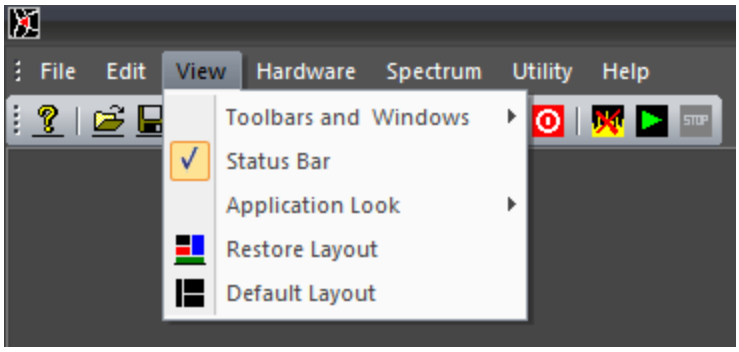


Figure 3.1.10. View menu.

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.

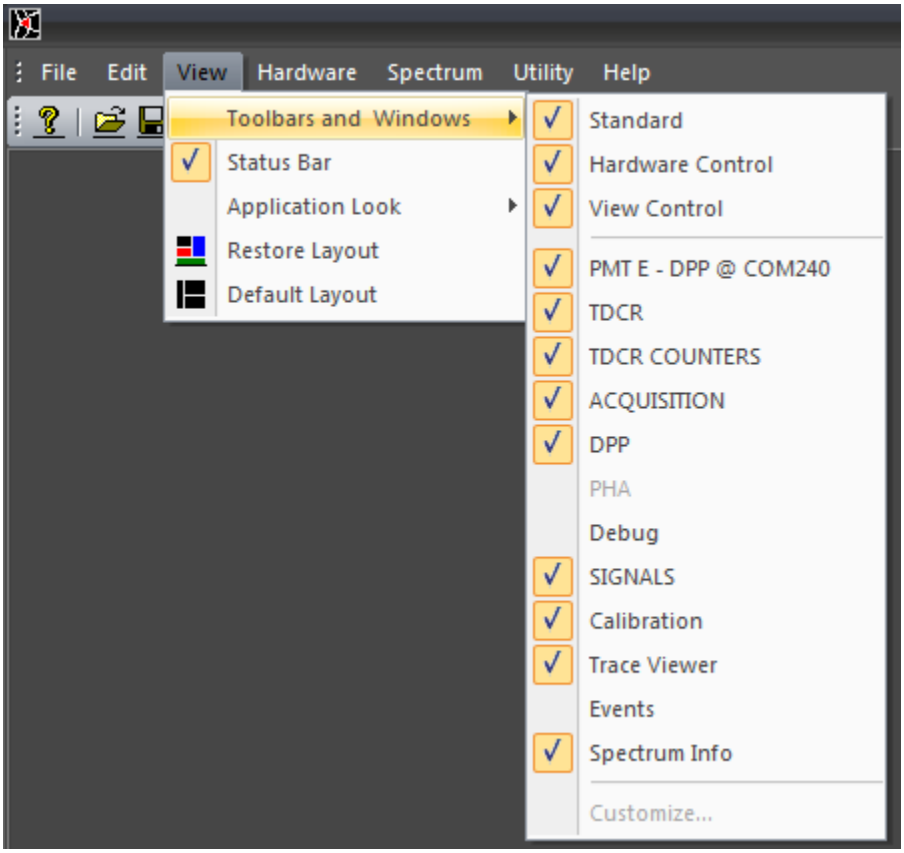


Figure 3.1.11. View menu → Toolbars and Windows options.

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.

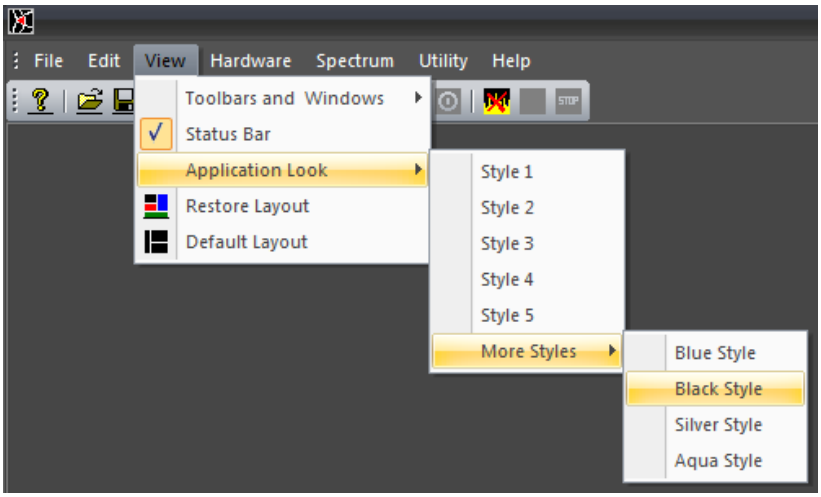


Figure 3.1.12. View menu → Application Look.

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.

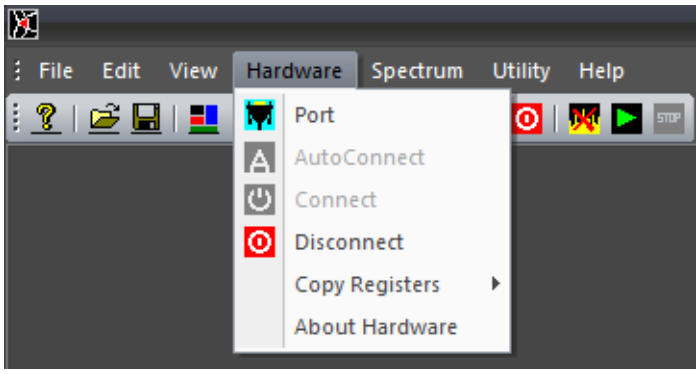


Figure 3.1.13. Hardware menu.

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.

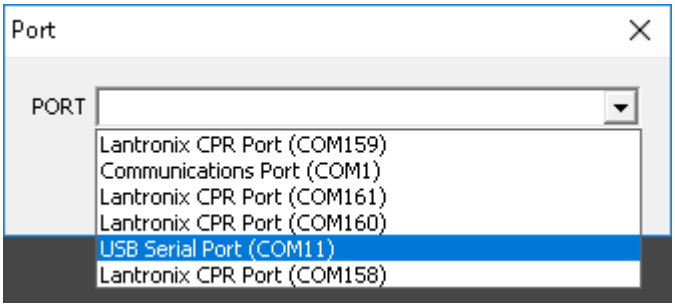


Figure 3.1.14. Available ports (Hardware > Port).

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**.

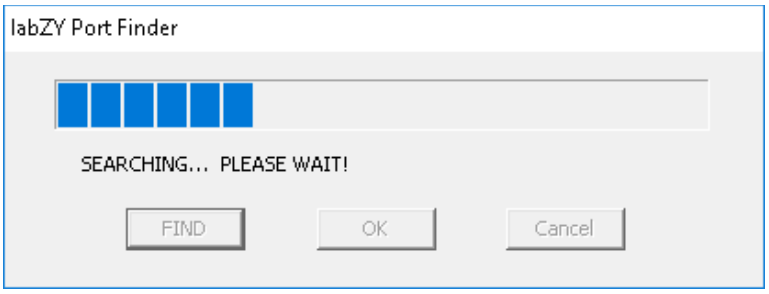


Figure 3.1.15. labZY Port Finder window during a search.

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.

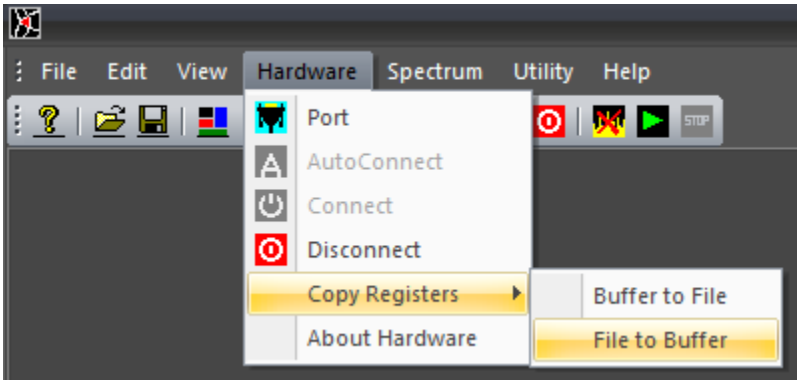


Figure 3.1.16. Hardware menu → Copy Registers options.

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.

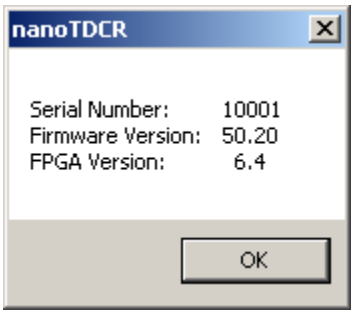


Figure 3.1.17. About hardware

Spectrum

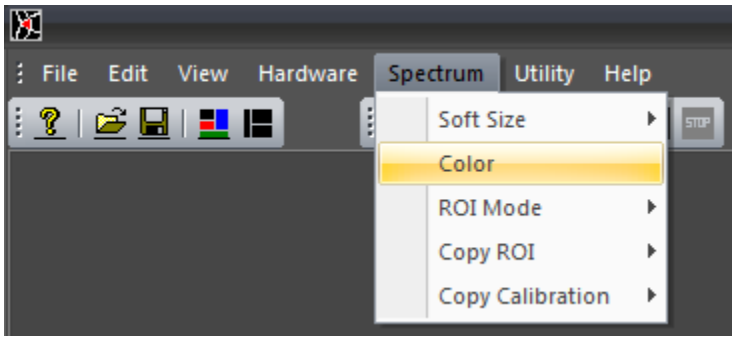


Figure 3.1.18. Spectrum menu.

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.

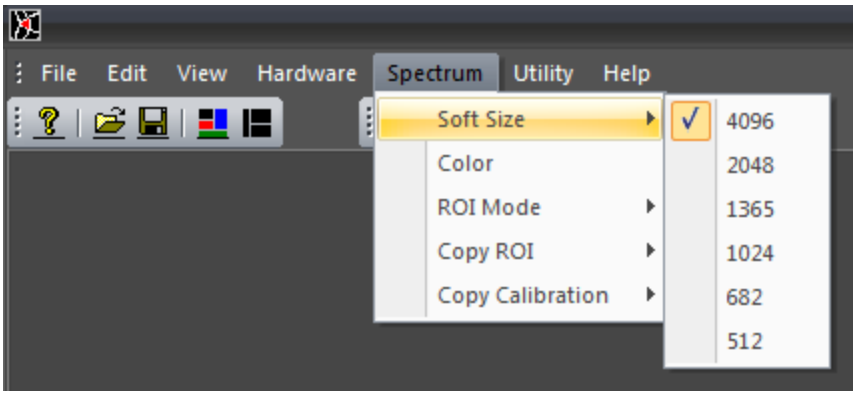


Figure 3.1.19. Spectrum menu → Soft Size options.

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.

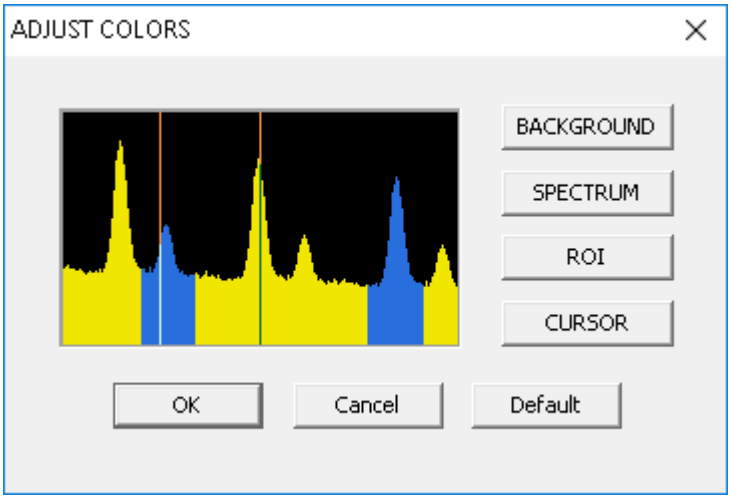


Figure 3.1.20. Adjust Colors Dialog.

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.

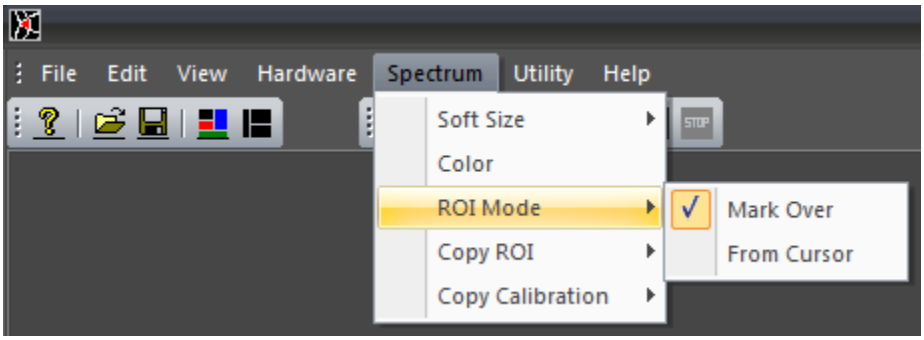


Figure 3.1.21. Spectrum menu → ROI Mode options.

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.

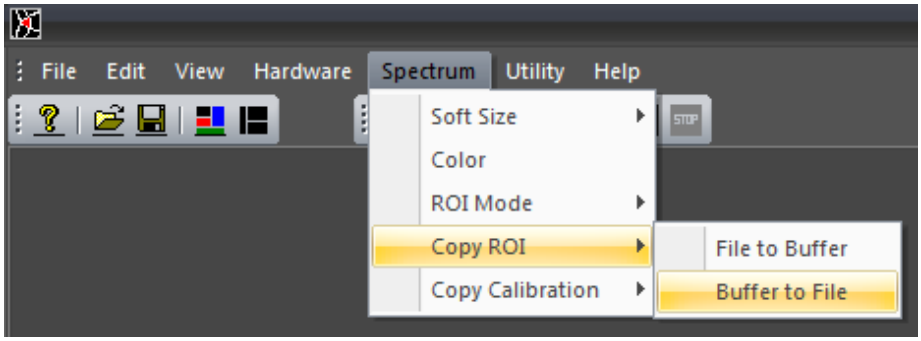


Figure 3.1.22. Spectrum menu → Copy ROI options.

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.

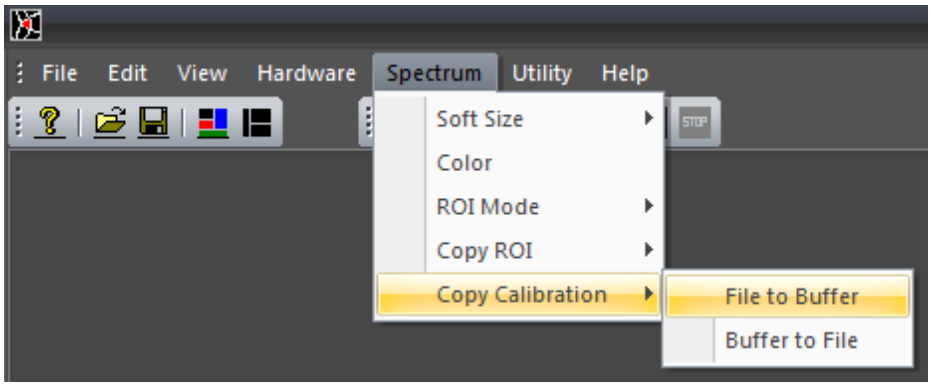


Figure 3.1.23. Spectrum menu → Copy Calibration options.

Utility

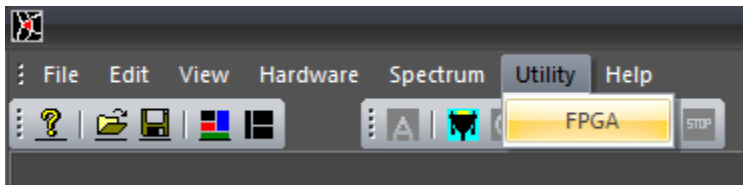


Figure 3.1.24. Utility menu.

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.

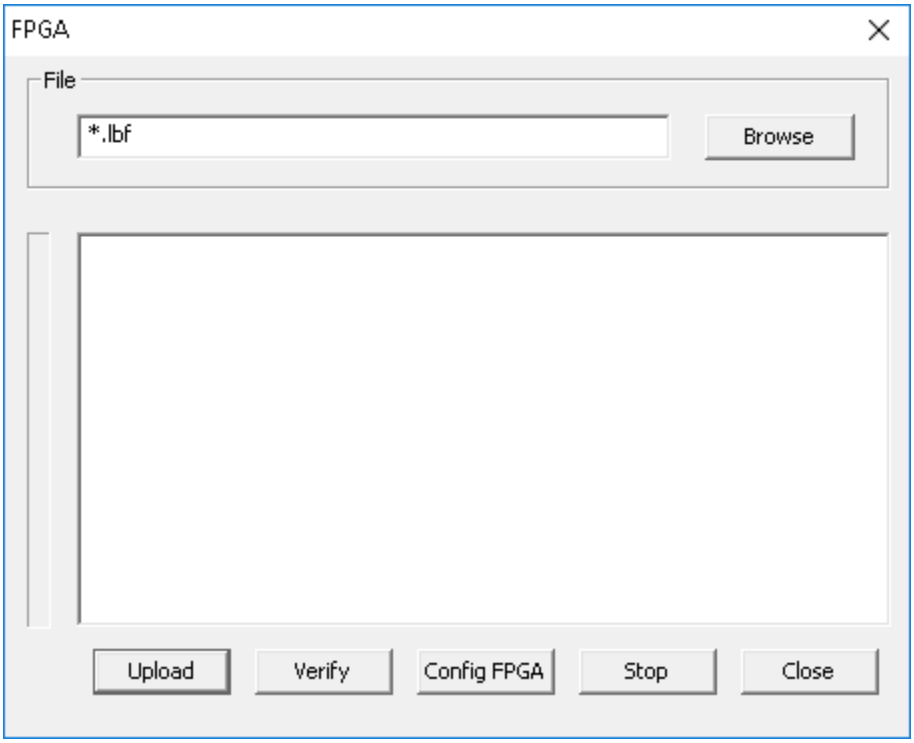
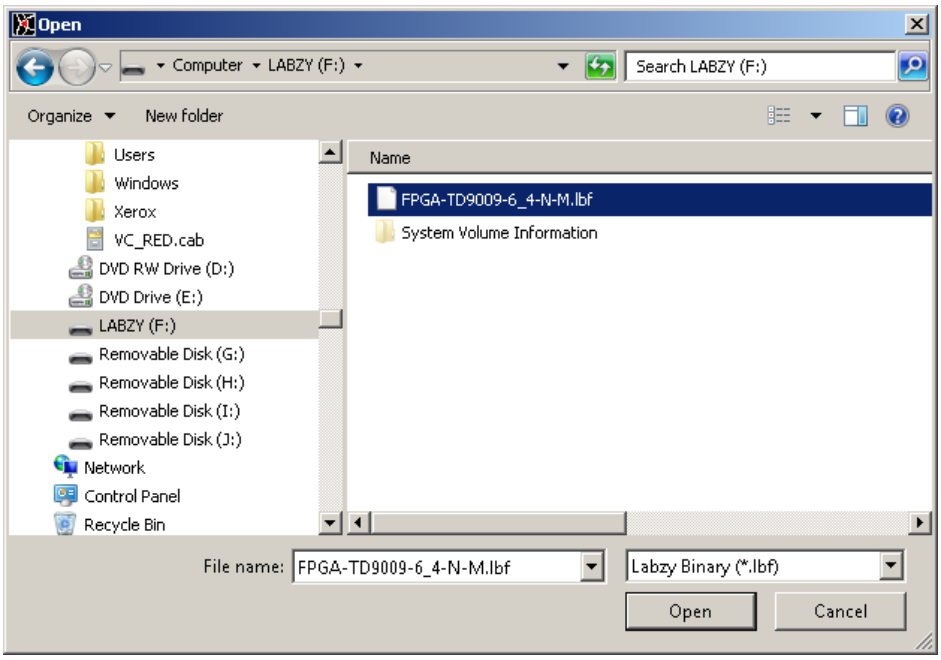


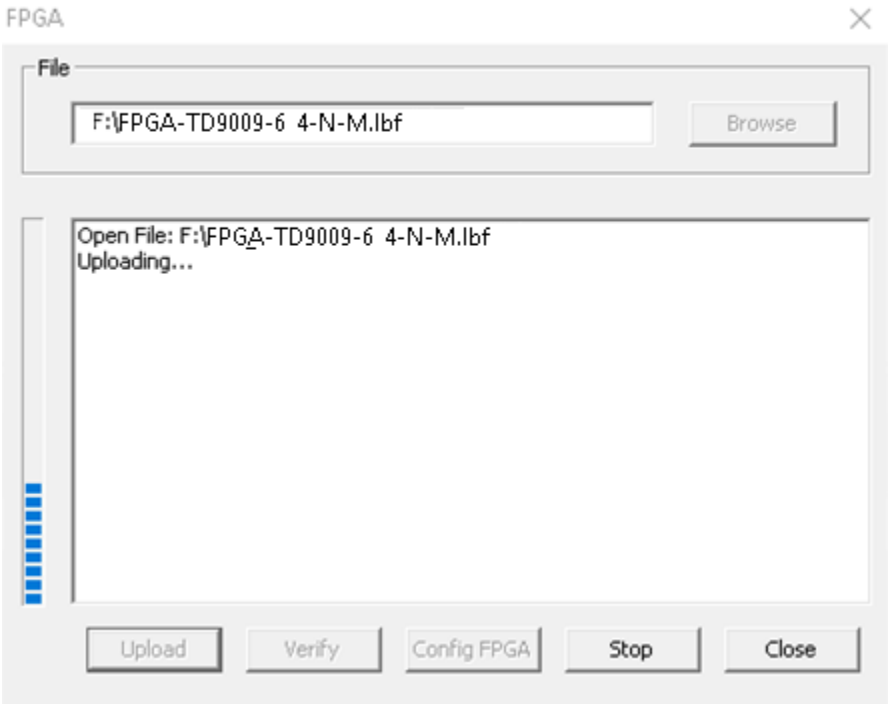
Figure 3.1.25. The **FPGA** dialog.

To upload an FPGA design, execute the following steps:

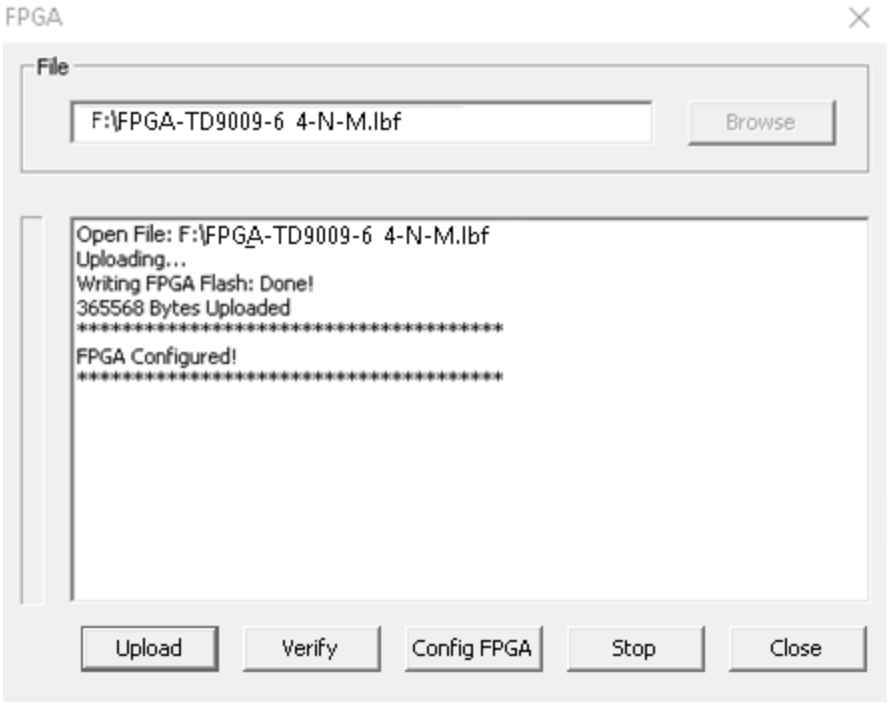
1) Press the button "**Browse**" to display the "**Open**" dialog. Browse to the directory of the FPGA design file with the extension "**.lbf**". Select the file and open it by pressing the "**Open**" button.



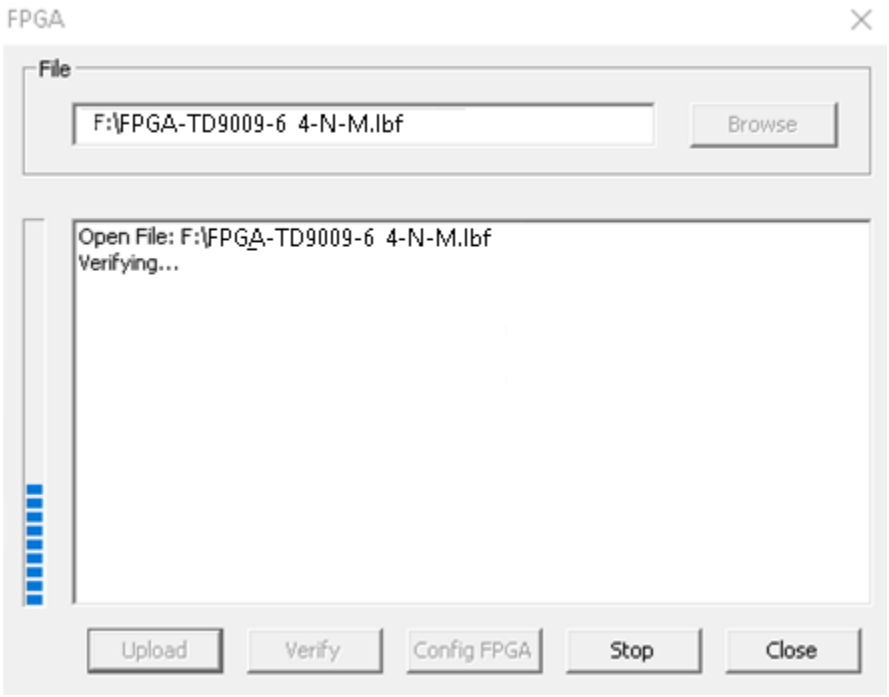
2) Press "**Upload**" and wait until the design programming file is uploaded. If the upload fails, repeat this step.



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

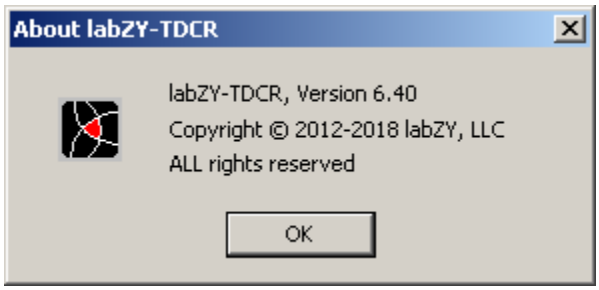


Figure 3.1.26. About labZY-TDCR window.

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).

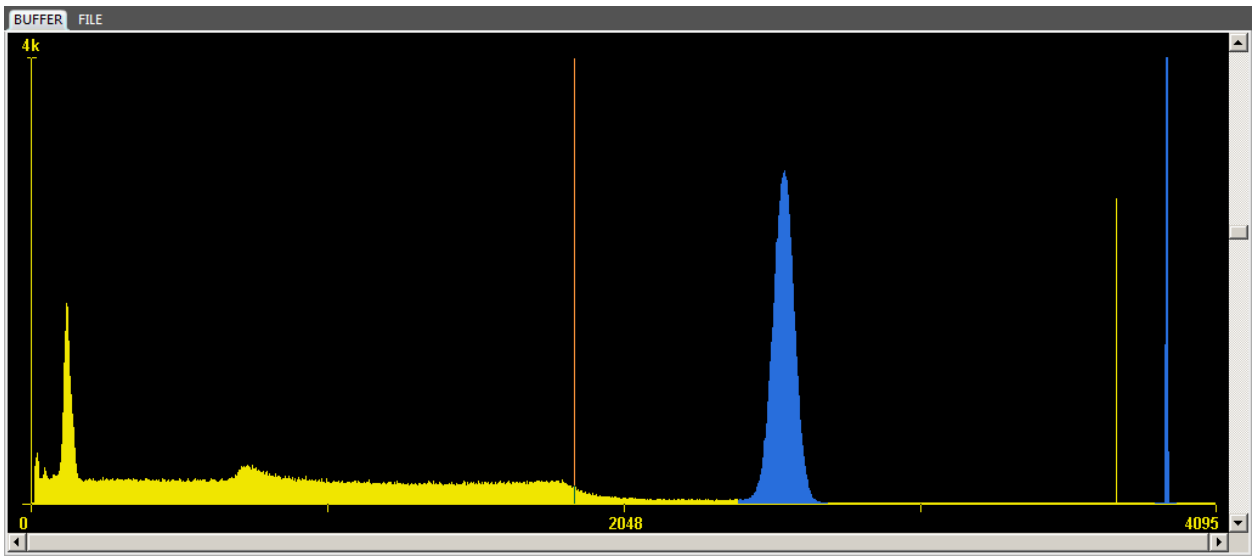


Figure 3.2.1. Sample display of a spectrum.

DPP Window

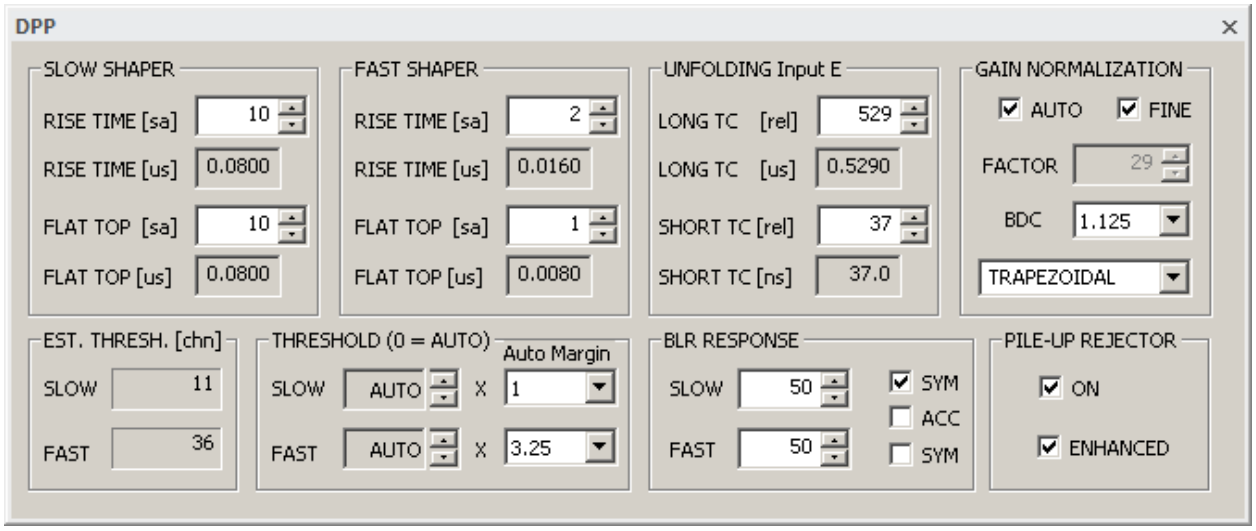


Figure 3.2.2. DPP Window.

The DPP Window contains various controls that are related to the Digital Pulse Processor (DPP). Using these controls, the apropriate 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.

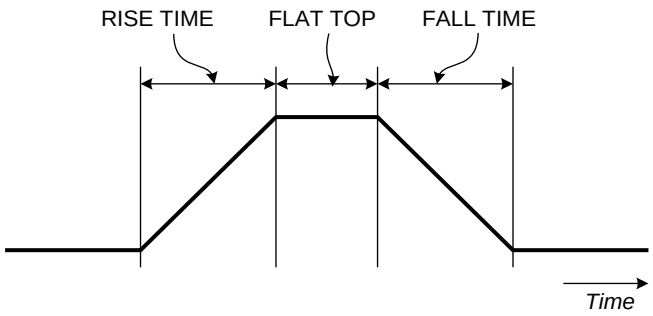


Figure 3.2.3. Trapezoidal pulses; FALL TIME = RISE TIME

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 equiped 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 ewaluated and displayed regardeles 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 coresponding 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.

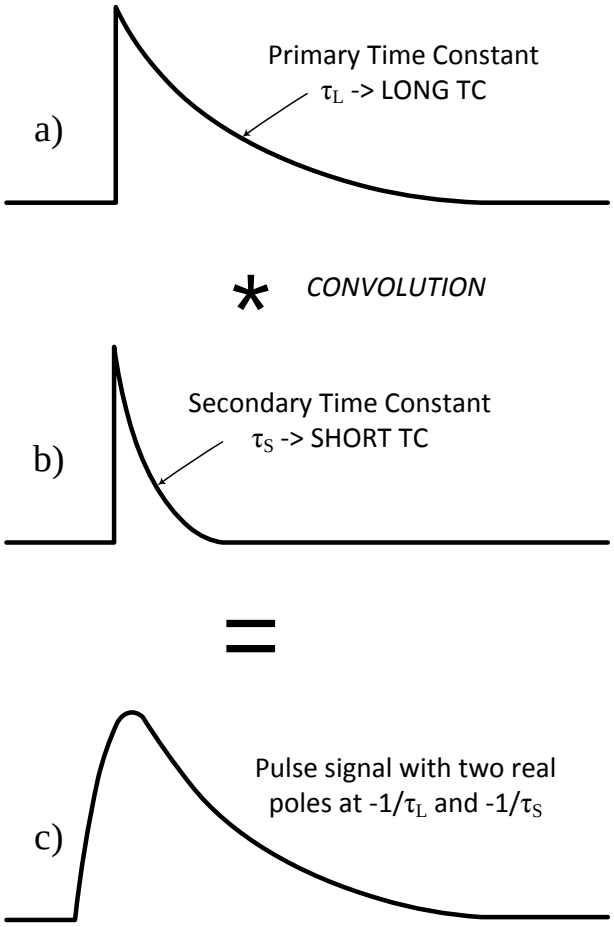


Figure 3.2.4. A pulse signal is characterized by LONG TC and SHORT TC.

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.

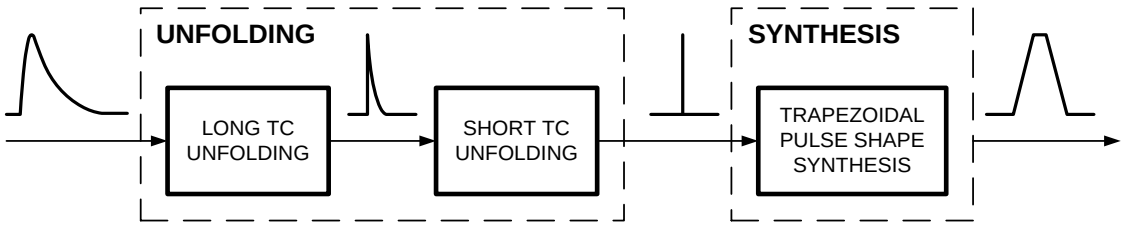


Figure 3.2.5. Unfolding to synthesis.

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.

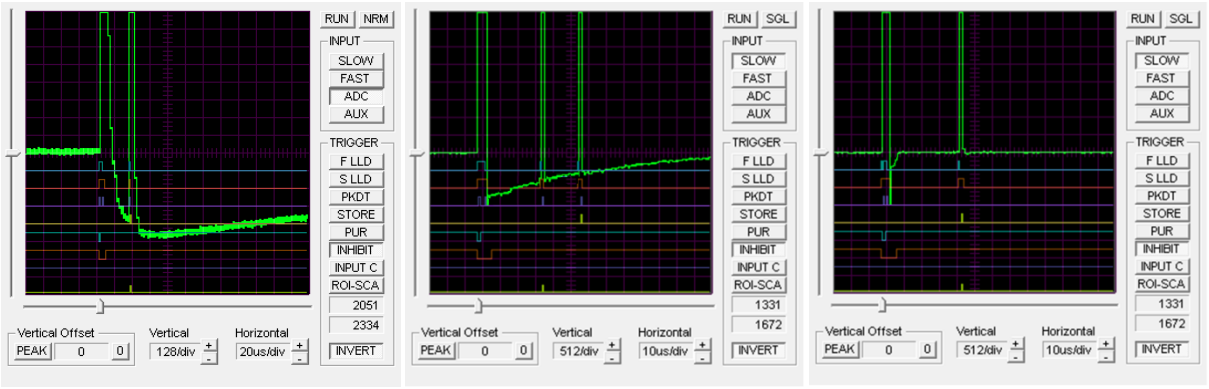
The trapezoidal pulse shape synthesis can be represented as a convolution of two rectangular impulse responses. The peak value of the trapezoidal pulse represents the area under the shorter of the two rectangular impulse responses. The rise time of the trapezoidal pulse is equal to the width of the shorter 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 scinitllators) 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. NaI(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 inversly proportional to the value set for SLOW or FAST. A smaller number means more agressive 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 recomended

for the SLOW shaper. Depending on the counting rates and the undershoots of the detector signals, the SYM mode will require carefull 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 - INHIBIT signals 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.



a) b) c)

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 anlysis** 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.

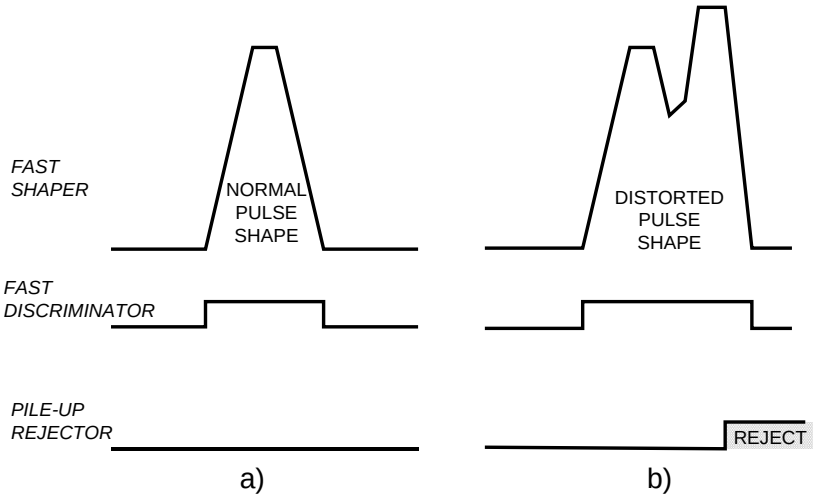


Figure 3.2.7. a) Pile-up free fast shaper/discriminator; b) fast shaper pile-up and pulse-shape distortion.

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.

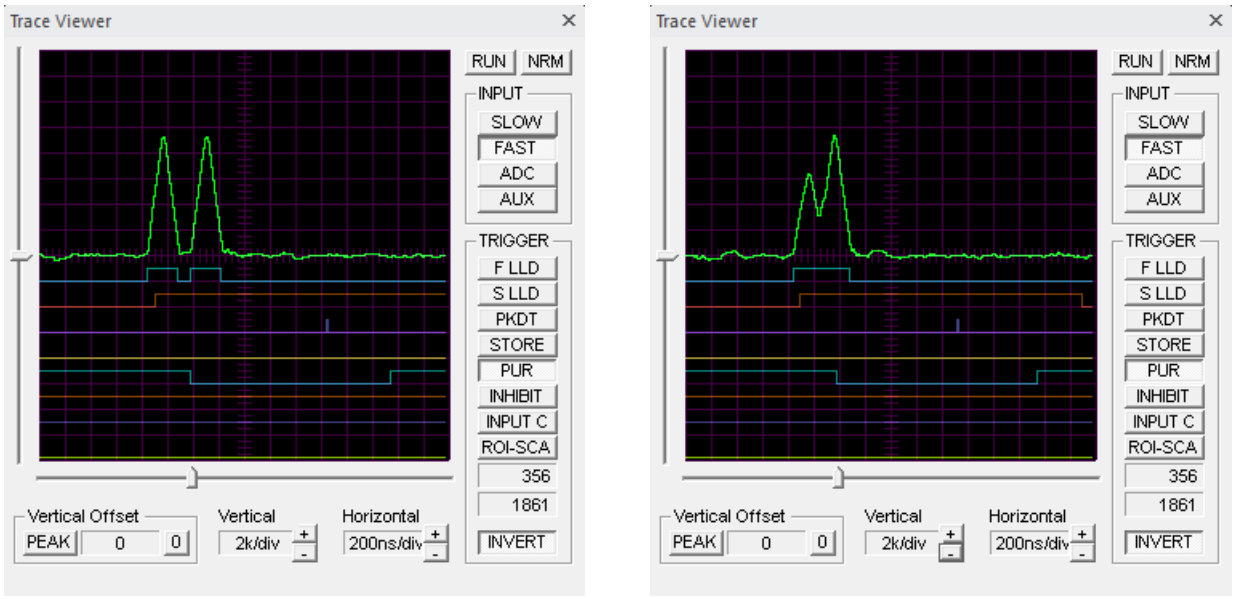


Figure 3.2.8. a) Traditional pile-up rejection; b) enhanced pile-up rejection.

SIGNALS Window

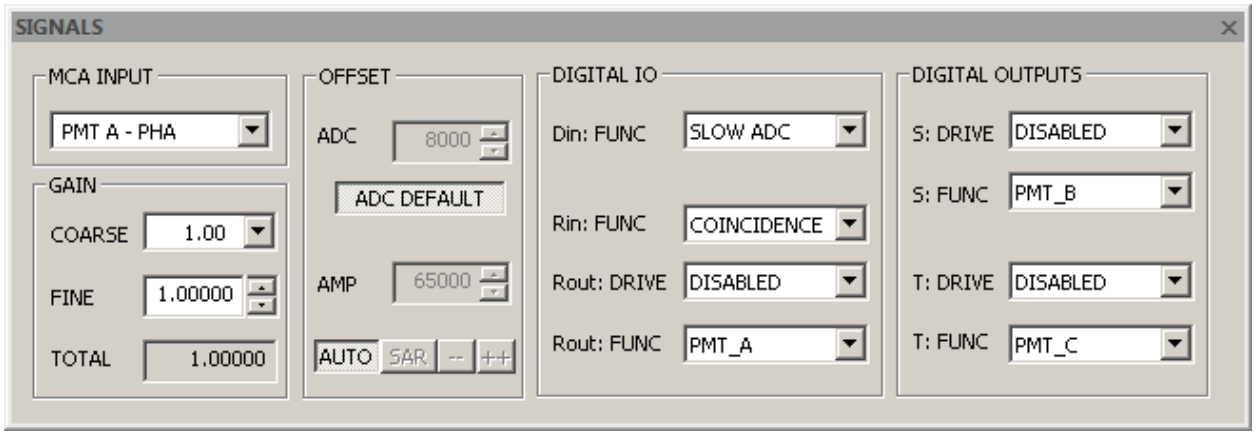


Figure 3.2.9. SIGNALS Window.

The SIGNALS Window contains the controls of the analog signals, analog signals-related functions, and configuration of the logic signals functions of the nanoTDCR.

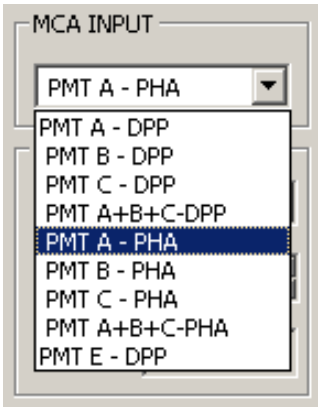


Figure 3.2.10. Analog Inputs A/B options.

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.

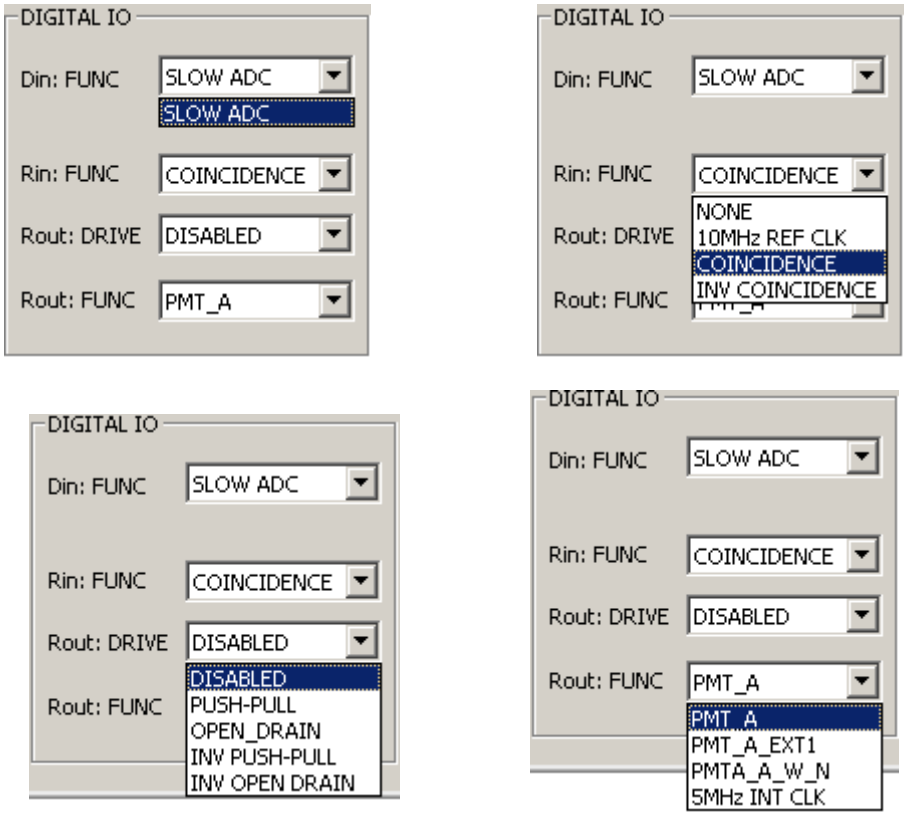


Figure 3.2.11. DIGITAL IO options.

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 aplied 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.

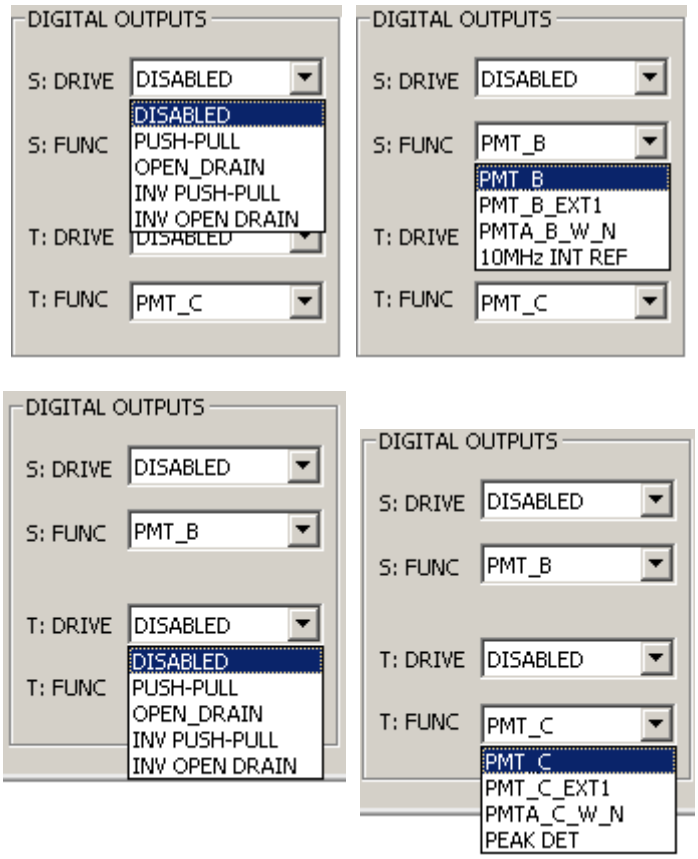


Figure 3.2.12. DIGITAL OUTPUTS configuration options.

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.

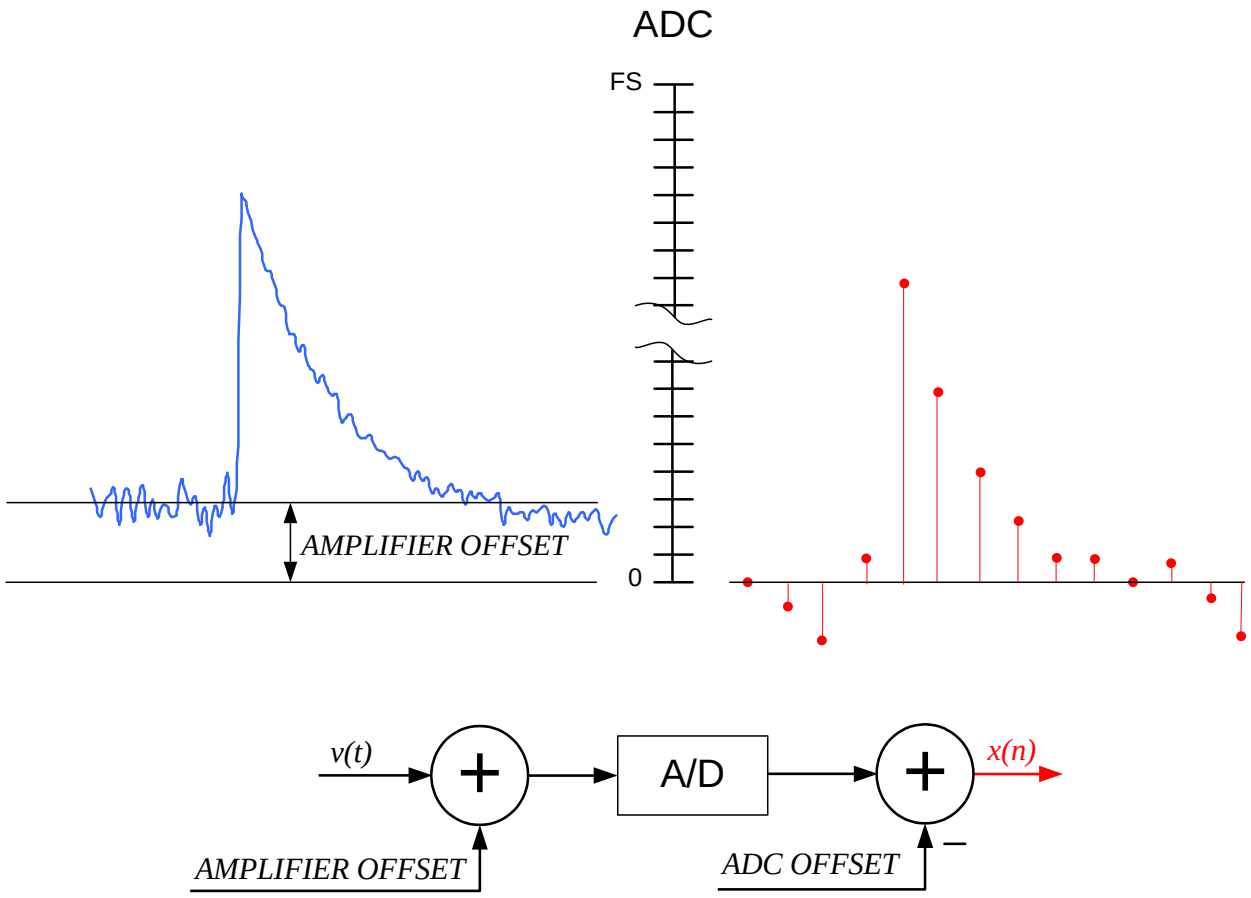


Figure 3.2.13. Offset cancellation.

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.

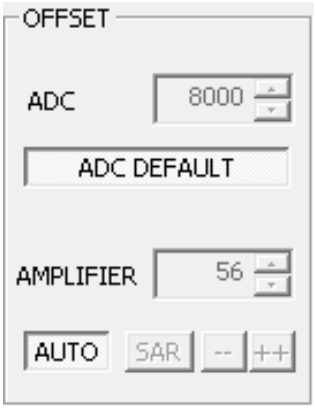


Figure 3.2.14. Offset group.

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 µs/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.

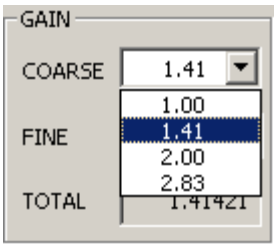


Figure 3.2.15. Coarse Gain selection.

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.

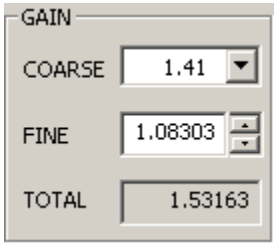


Figure 3.2.16. The fine gain control and the total gain field.

PHA Window

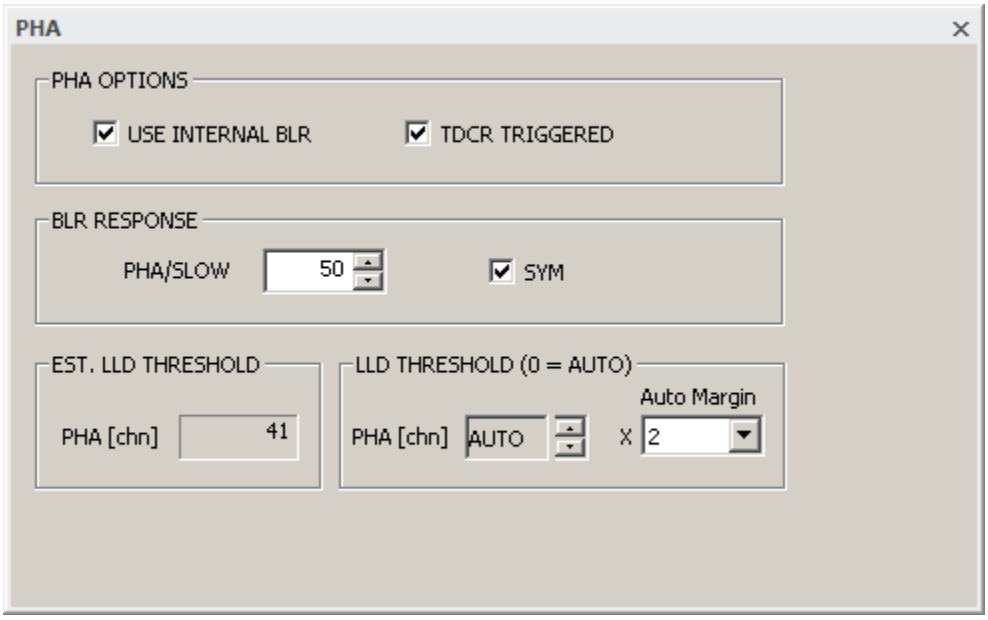


Figure 3.2.20. PHA Window

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 accuire pulse-heights of pulses that exceeds the TDCR threshold. That is, an adjustment of the TDCR threshold will afect the lower cut-off of the spectrum. This is especially isefull 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.

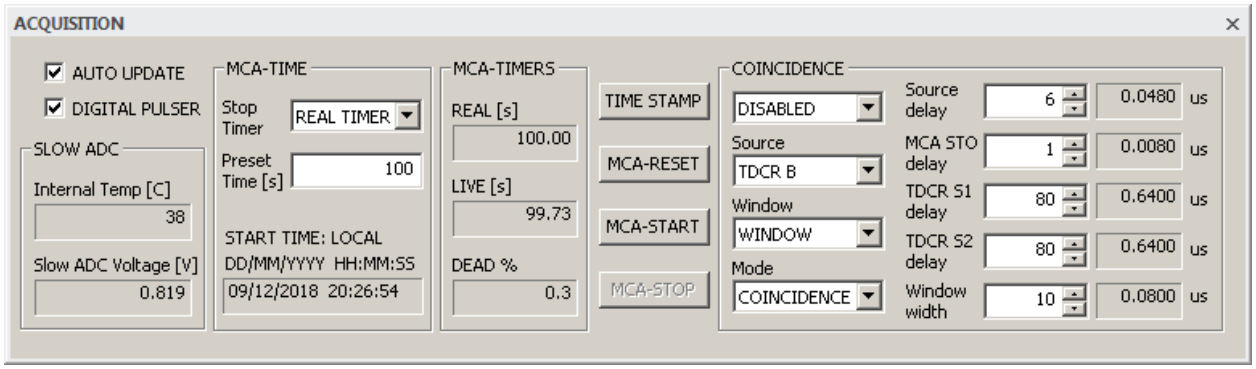


Figure 3.2.16. Acquisition Window.

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.

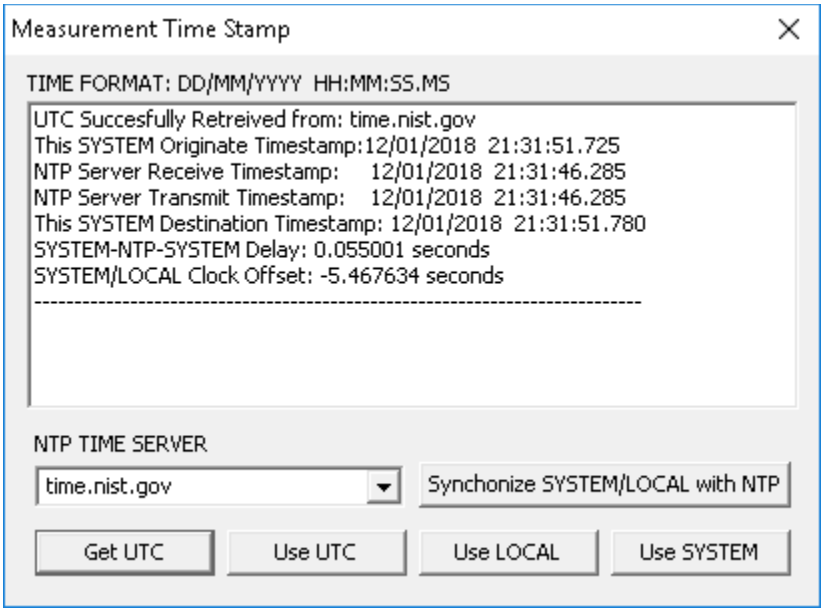


Figure 3.2.20. Timestamp Dialog.

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.

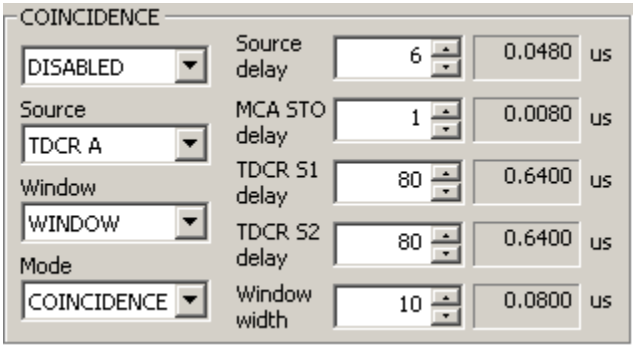
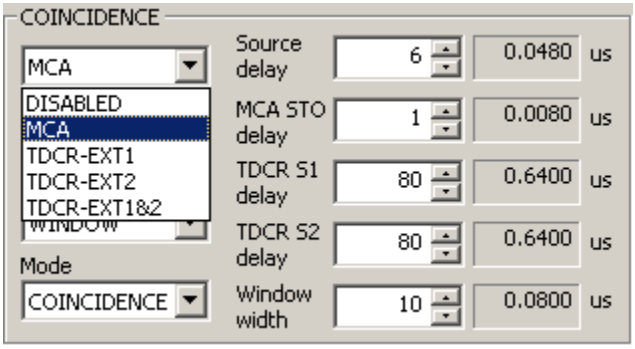
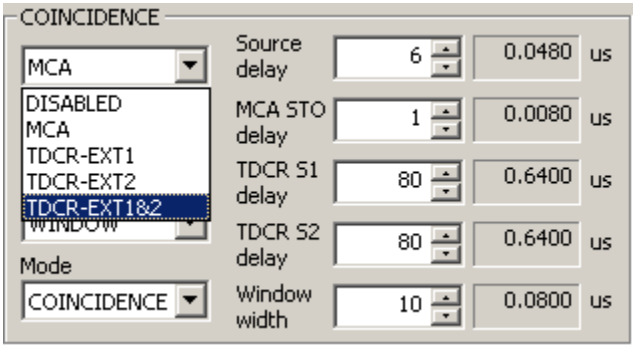


Figure 3.2.21. Coincidence Controls.

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.



a)



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

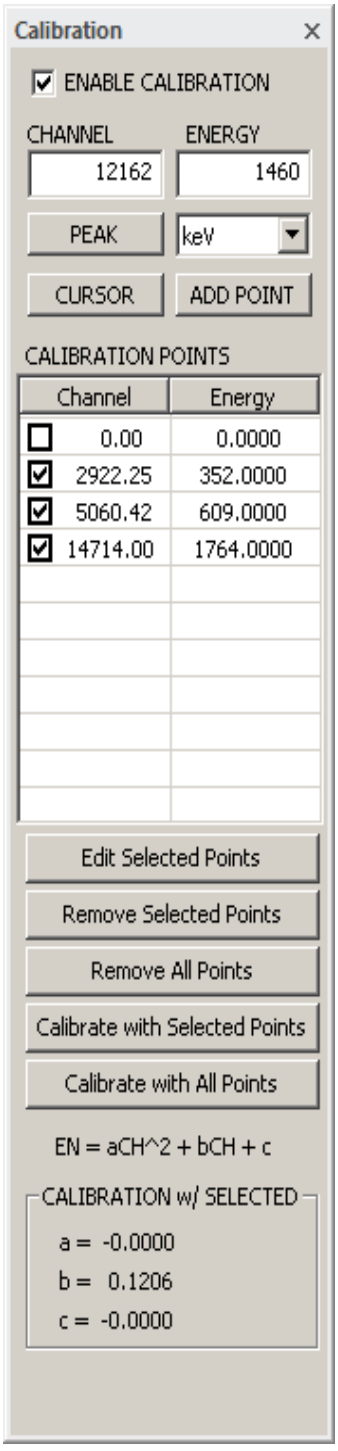


Figure 3.2.23. Calibration

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 = ***a***CH^2 + ***b***CH + ***c***.

To set the calibration coefficients, up to 10 channel-energy points can be used. The available points are listed in the CALBIRATION 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.

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.

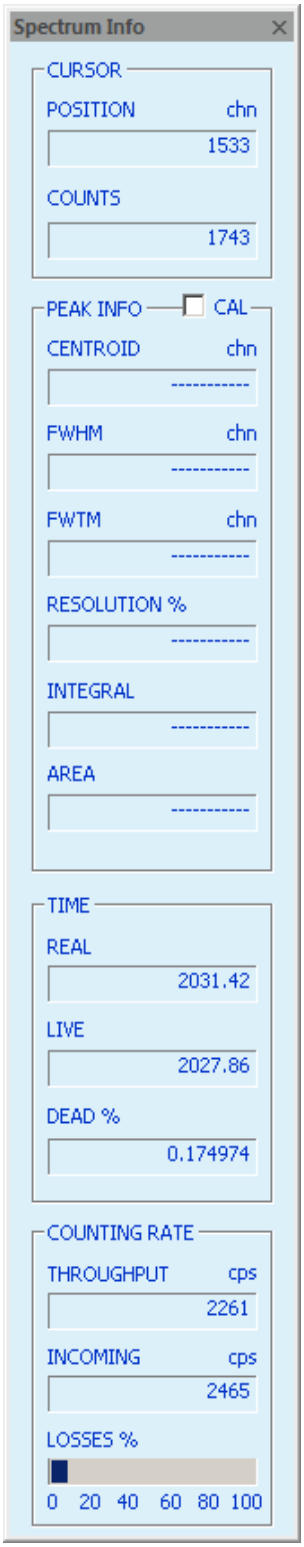


Figure 3.2.24. Spectrum Info

Trace Viewer Window

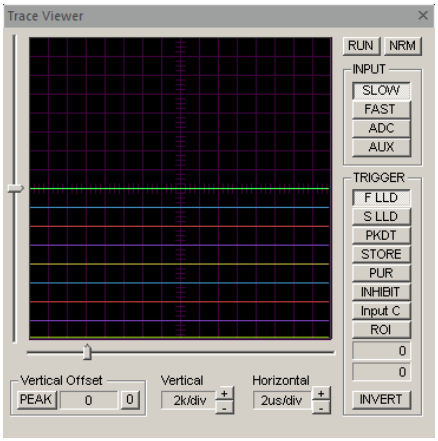


Figure 3.2.19. Normal size Trace Viewer Window.

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 affect if the size of the frame becomes smaller than the normal size.

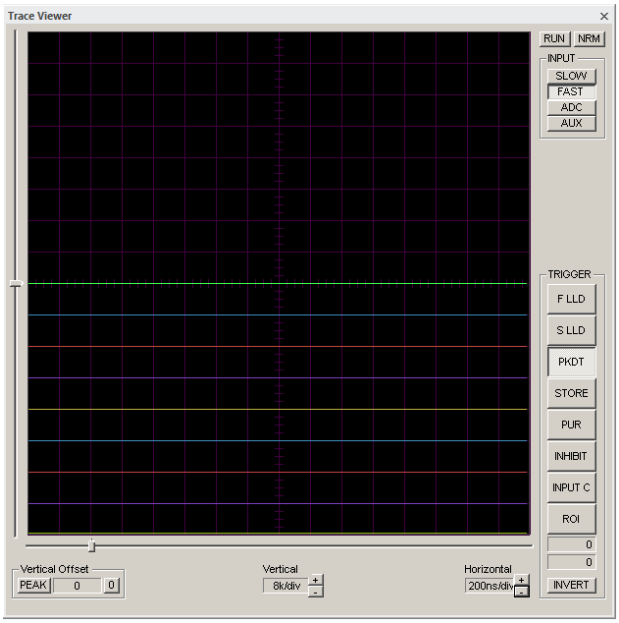


Figure 3.2.20. Large Size Trace Viewer Window

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.

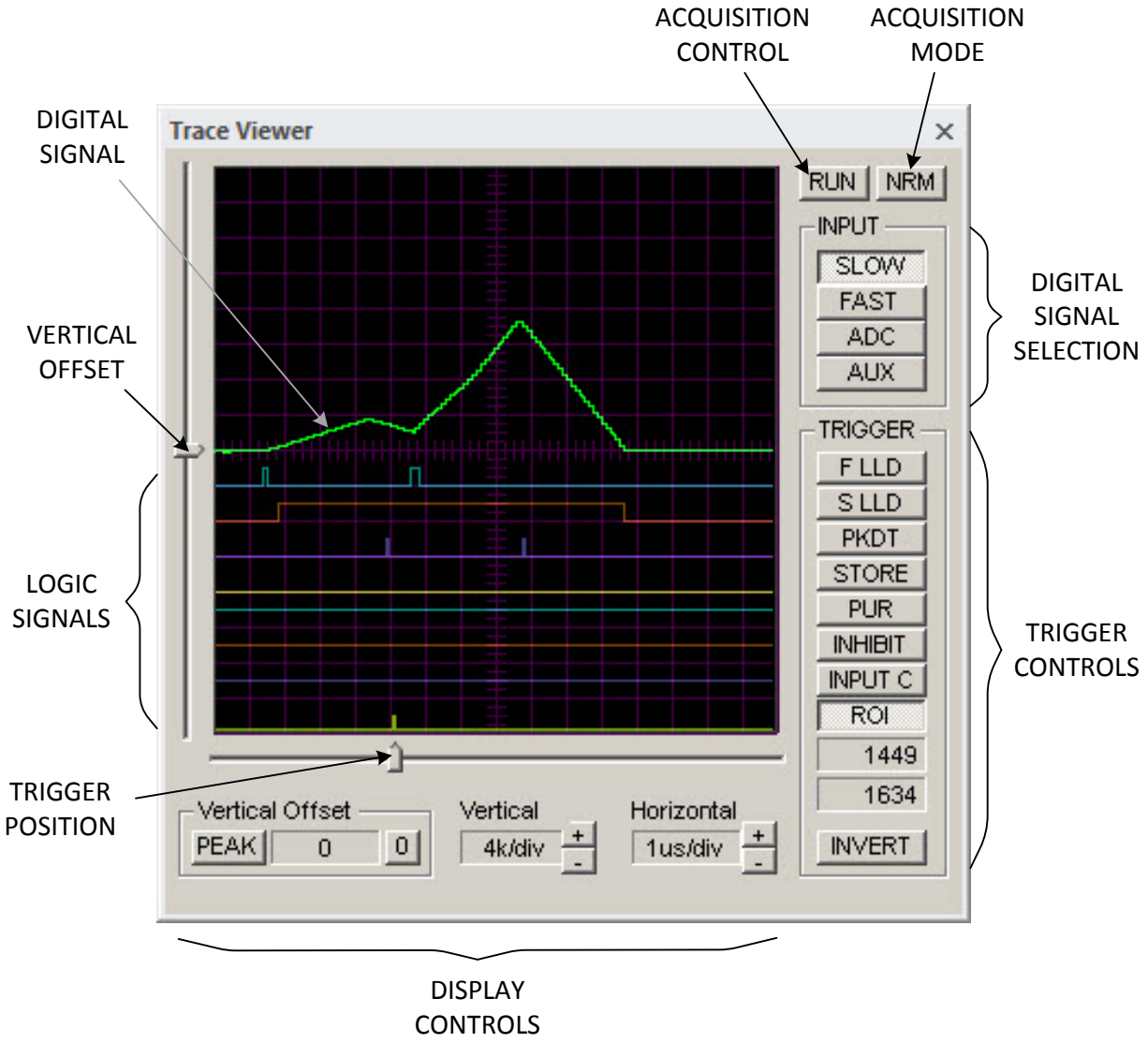


Figure 3.2.21. Controls and features of the Trace Viewer.

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.

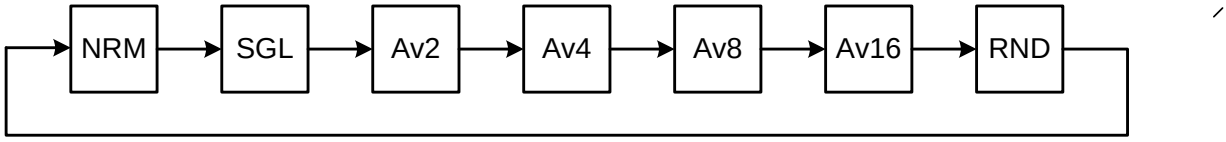


Figure 3.2.22. Acquisition Mode selection sequence using the ACQUISITION MODE button

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

- NRM *Continuous, triggered acquisition. No averaging of the digital signal.*
- SGL *Single, triggered acquisition. No averaging of the digital signal.*
- Av2 *Continuous, triggered acquisition. 2 samples averaging of the digital signal.*
- Av4 *Continuous, triggered acquisition. 4 samples averaging of the digital signal.*
- Av8 *Continuous, triggered acquisition. 8 samples averaging of the digital signal.*
- Av16 *Continuous, triggered acquisition. 16 samples averaging of the digital signal.*
- RND *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.

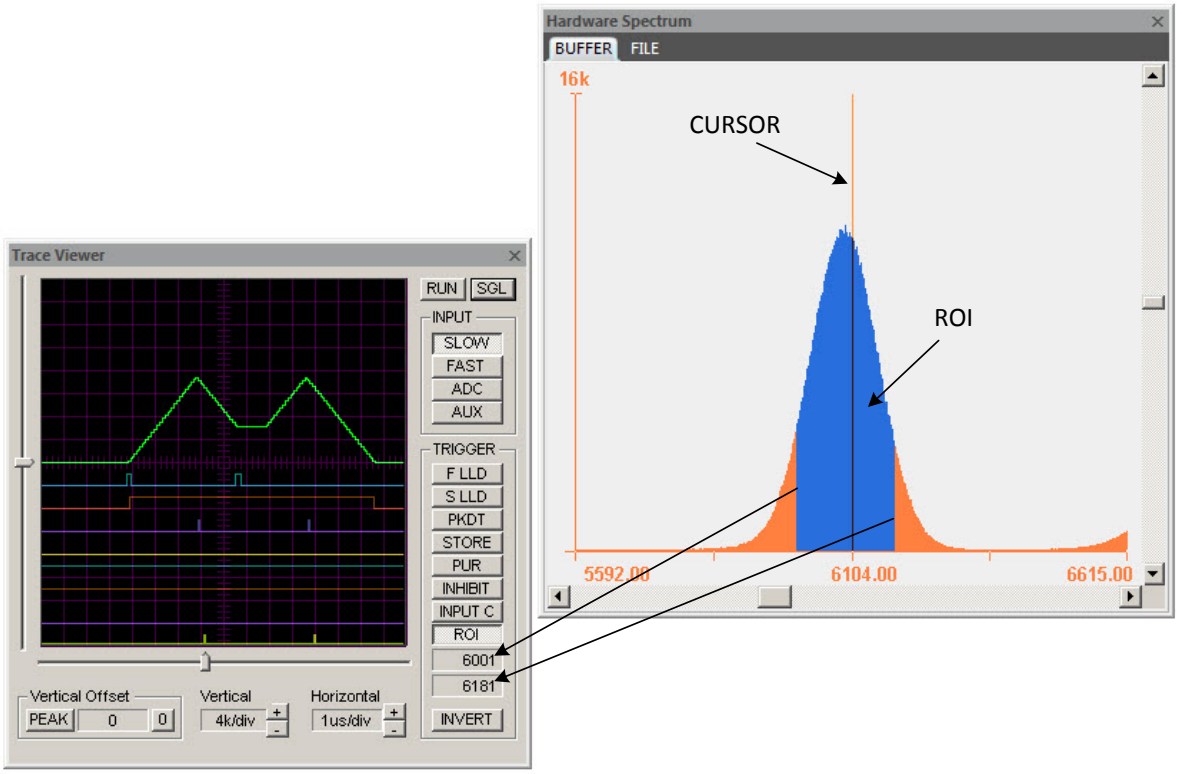


Figure 3.2.23. Setting the ROI trigger

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

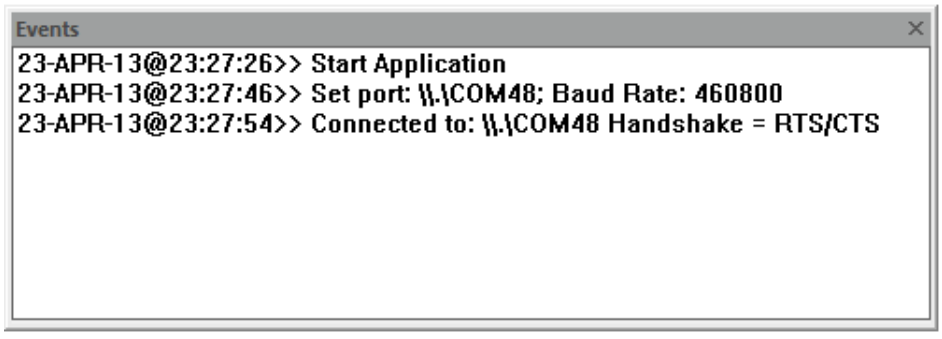


Figure 3.2.25. Events Window.

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.

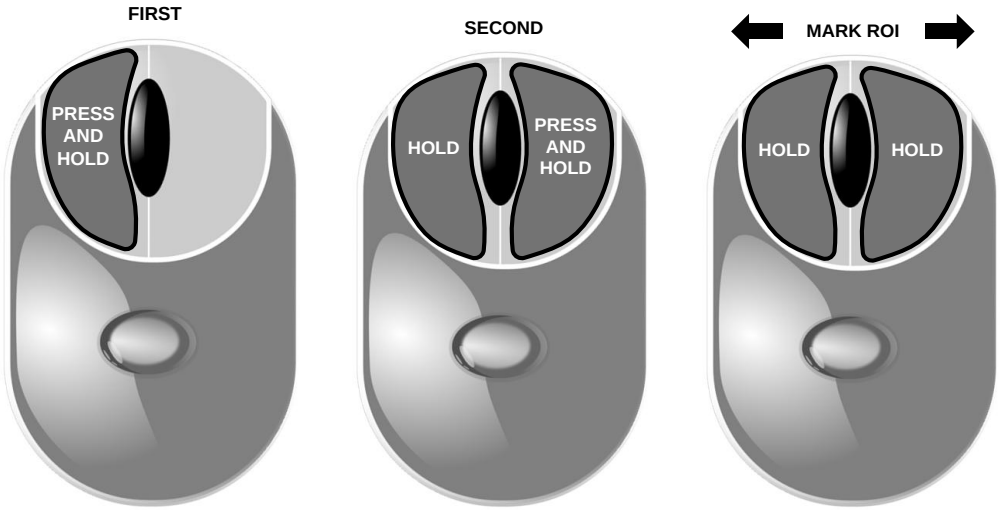


Figure 3.4.1. How to mark an ROI using the mouse.

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

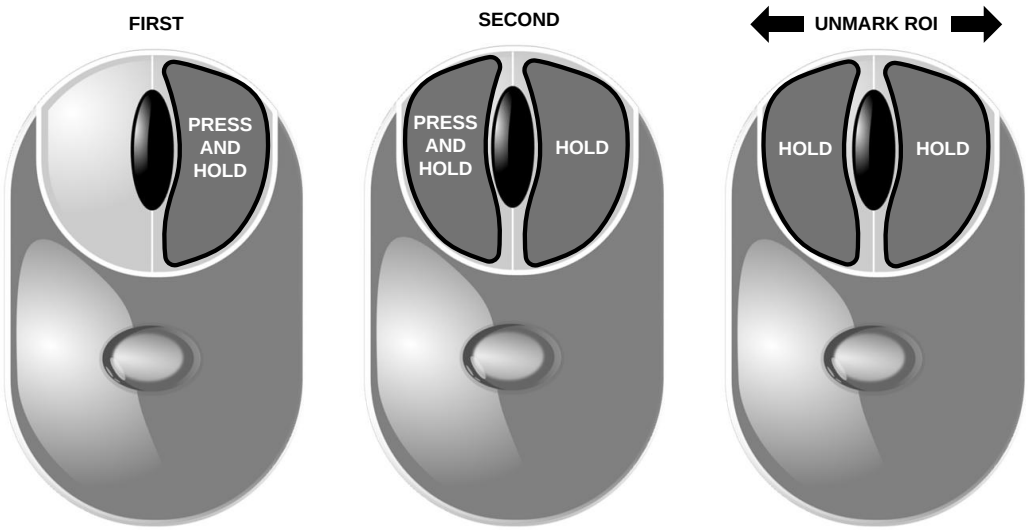


Figure 3.4.2. How to unmark an ROI using the mouse.

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.

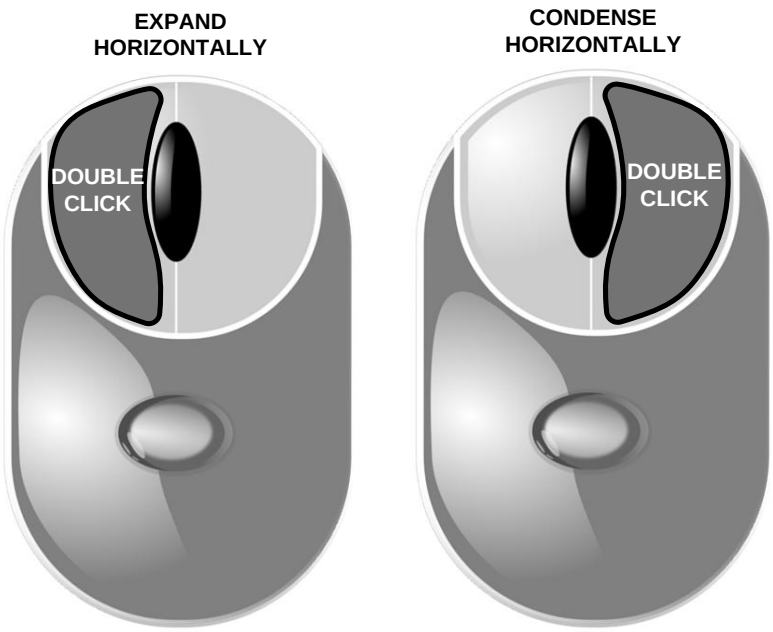


Figure 3.4.3. How to expand and condense the spectrum display horizontally.

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.

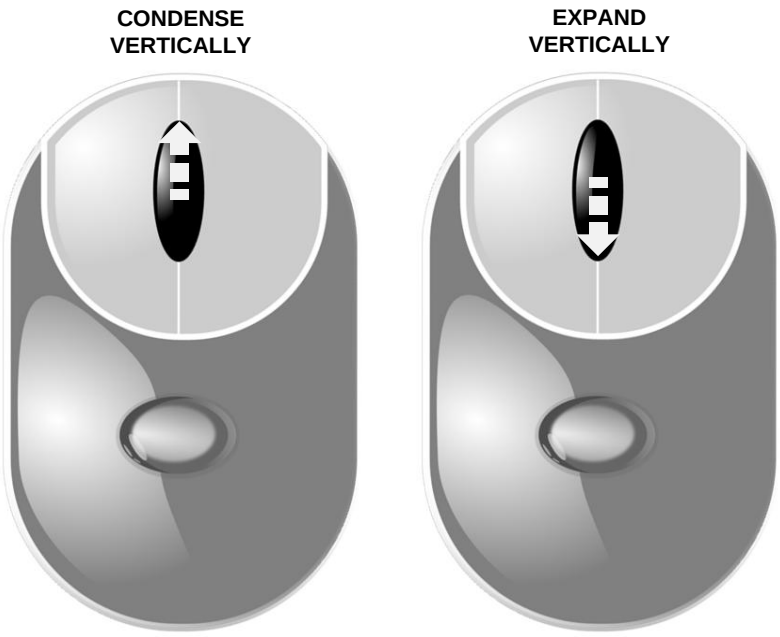


Figure 3.4.4. How to expand and condense vertically the spectrum display.

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 Coctail, 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 (.lts)

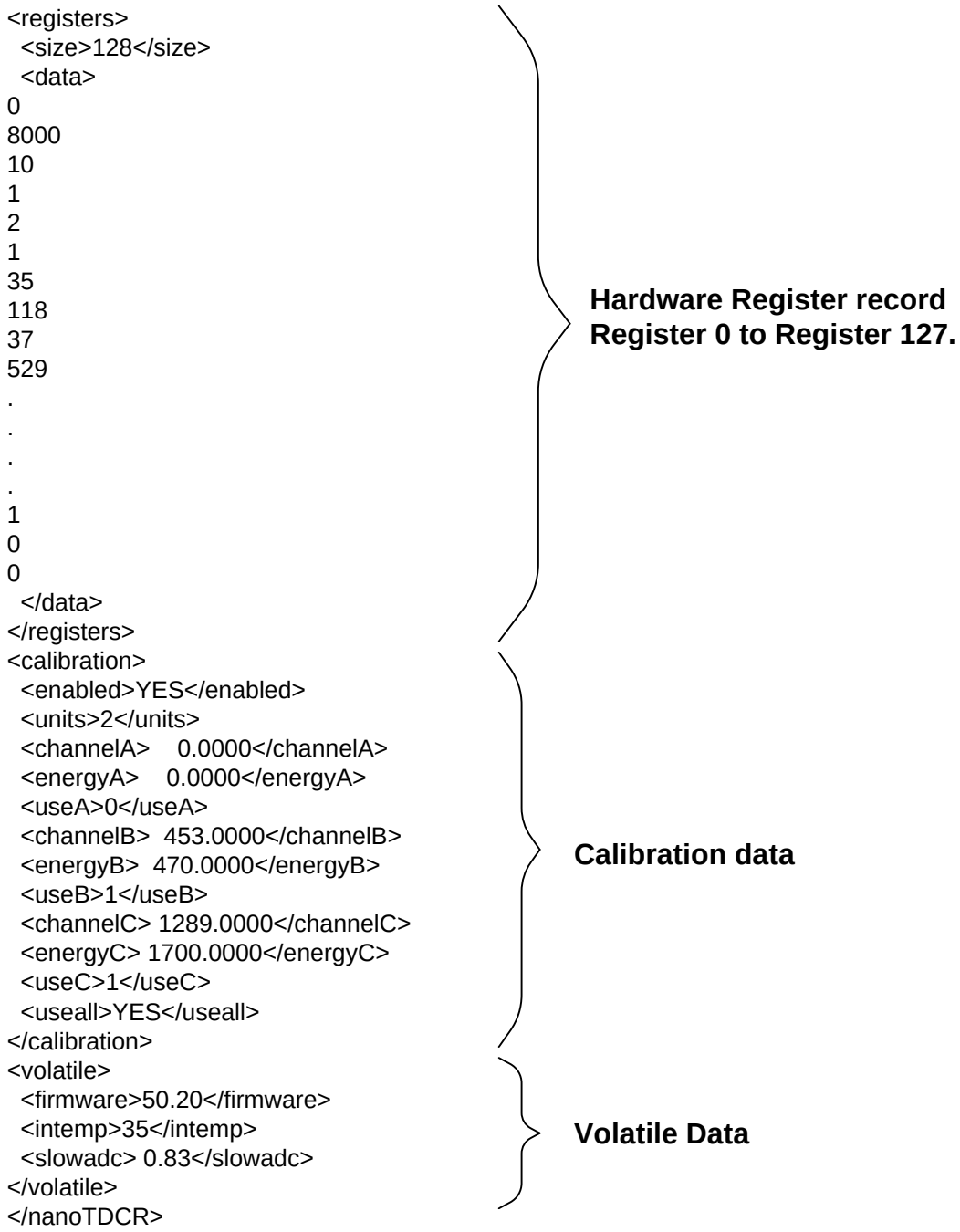
```
<?xml version="1.0"?>
<nanoTDCR>
 <serialnumber>10001</serialnumber>
<spectrum>
  <tag>labZY-TDCR Input A Spectrum</tag>
  <hardsize>4096</hardsize>
  <softsize>4096</softsize>
  <offset>4096</offset>
  <data>
0
0
0
12
17
82
44
.
.
.
346
+567
+1054
+1109
+985
+605
588
561
500
389
.
.
.
.
+0
+5
2
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>
```

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.


<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>
Hardware Register record
Register 0 to Register 127.
Calibration data
Volatile Data

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.

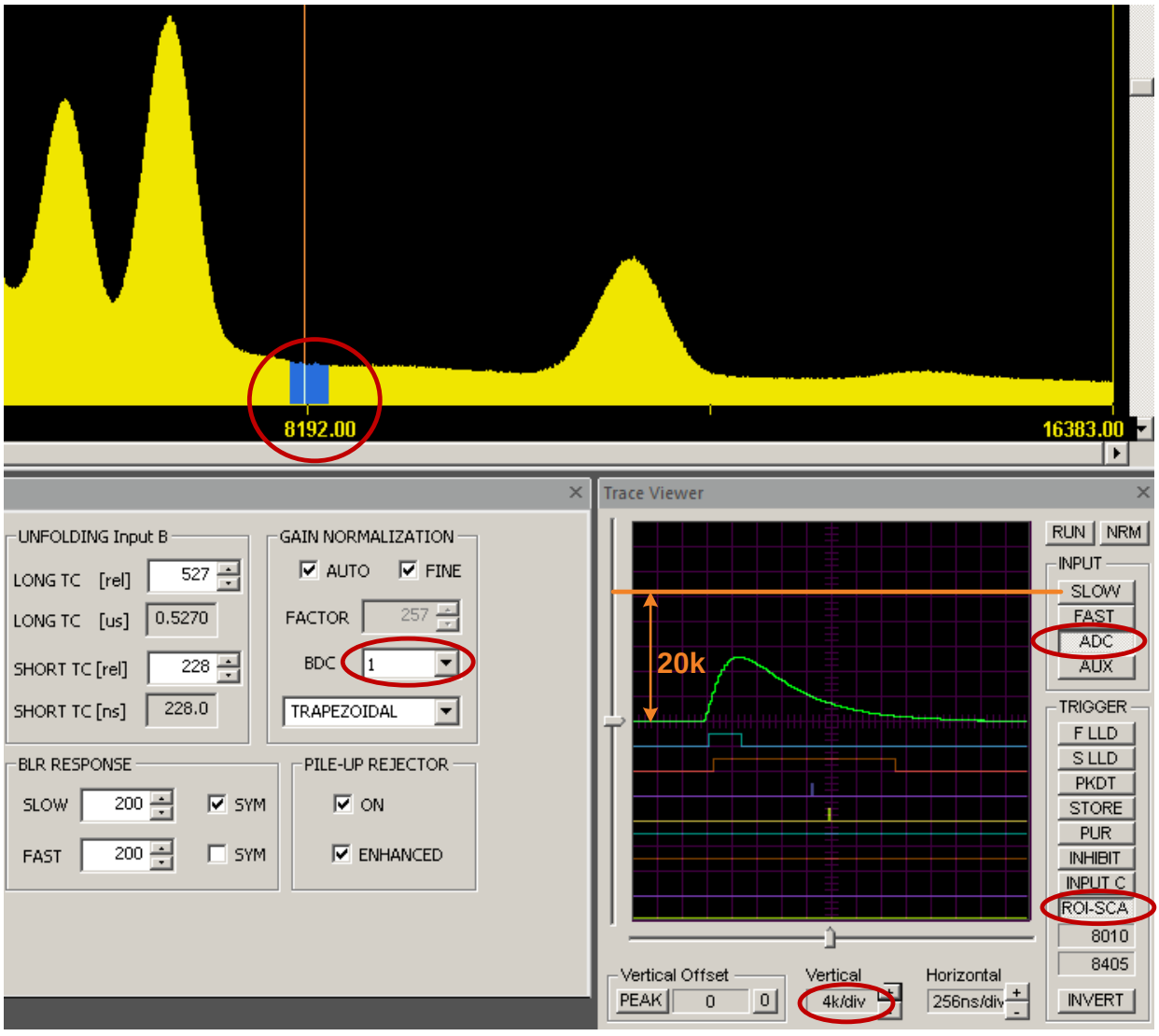


Figure B1. Example BDC that is not optimally adjusted.

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.

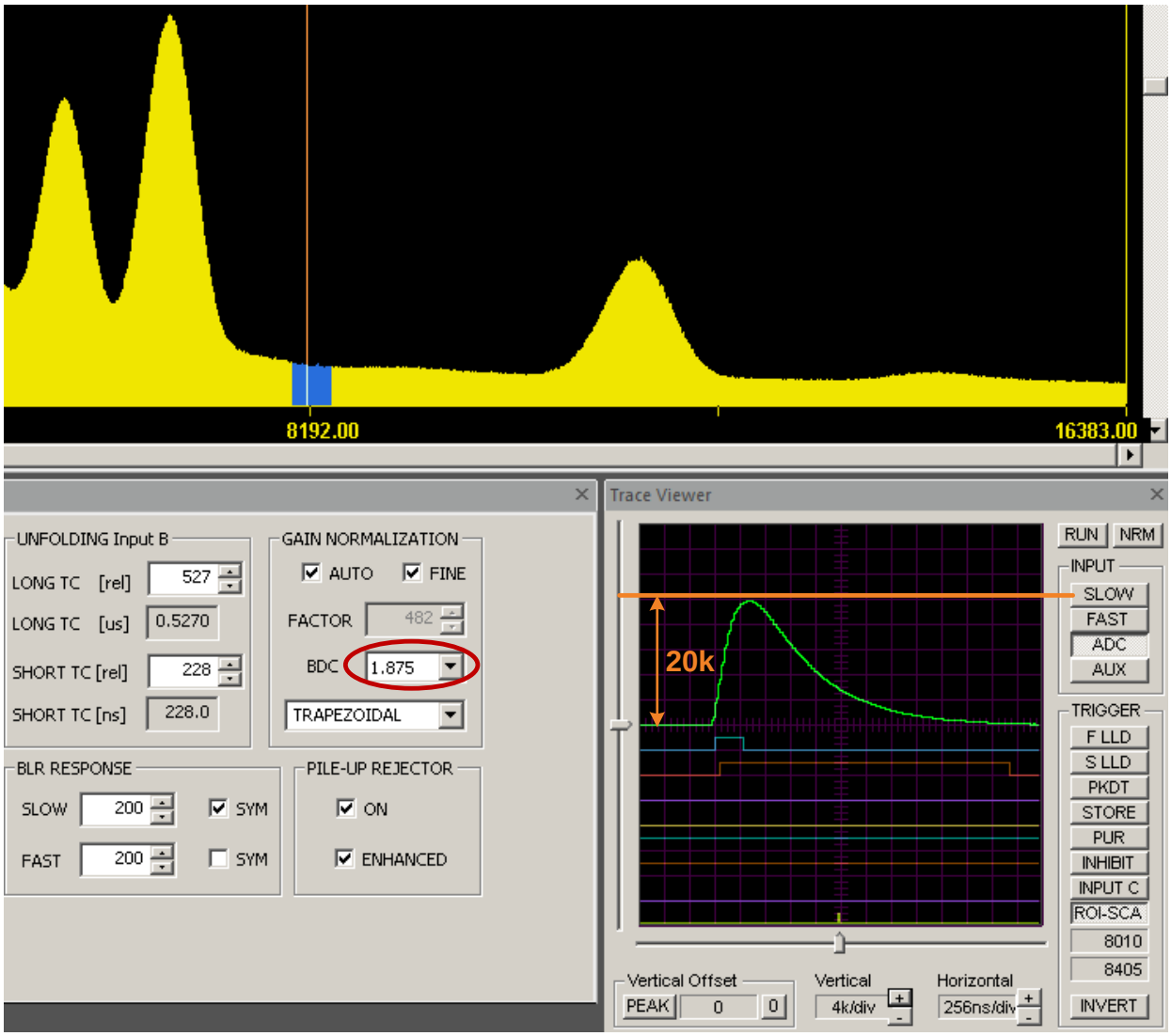


Figure B2. Example optimally adjusted BDC.