Software User Manual

labZY-PSD

Versions 2.50 to 2.99

Revision 1a

Contents

Overview and Installation

Software Overview

The labZY-PSD application application is compatible with nanoPSD pulse-shape discriminating spectrometer. The labZY-PSD application provides an interface to nanoPSD, with the ability to set device operating parameters and the pulse-shape discrimination criteria, verify correct device operation, and acquire spectral data. A pulse-shape signature spectrum and pulse-height spectra can be acquired simultaneously. Once the spectra are acquired from the hardware, they can be displayed and analyzed using basic spectroscopy and pulse-shape discrimination tools. The spectra can be stored in files for subsequent viewing and analysis.

NOTE: The nanoPSD is not a digitizer and the labZY-PSD is not a software to process digitized data stored in the computer. The nanoPSD is a real time spectrometer.

Unique Features

The labZY-PSD application has dedicated features allowing setup and control of the pulse-shape analysis and pulse-shape discrimination of the nanoPSD spectrometer. The nanoPSD records four spectra simultaneously. These spectra are displayed by labZY-PSD in four separate spectral windows. The first window (S0) always displays the Time-Invariant Pulse-shape Signature (TIPS) spectrum. The other 3 spectral windows (S1-S3) display pulse-height spectra. Using region of interest (ROI) from TIPS spectrum the pulse-shape discriminator can be set so that each pulse-height spectrum is acquired only for events corresponding to specific TIPS. Unique feature of nanoPSD and the labZY-PSD application is the ability to setup and perform simultaneous pule-shape and pulse-height discrimination.

labZY-PSD application has a dedicated features related to the pulse-shape analysis. One of these features is automatic reporting of the figure of merit (FOM) of the TIPS spectrum. The automatic FOM reporting uses two peaks which can be identified using ROIs. Once set the FOM reporting will be held in the computer memory and will be reloaded at subsequent execution of the labZY-PSD application..

The labZY-PSD application offers unique features that support the advanced functionality of the nanoPSD hardware including support of Spectrum Hard Size and Spectrum Soft Size. All spectra are recorded by the hardware at the finest channel resolution possible, or the largest number of channels per spectrum (4096 channels). The number of channels recorded by the hardware is called the Spectrum Hard Size. The hard size spectra are the only spectra that are transferred from the hardware to the labZY-PSD application. The software stores the transferred hard size spectra in its memory and files. The labZY-PSD application allows hard size spectra to be displayed and exported into a files as a Spectrum Soft Size which has fewer channels than the Spectrum Hard Size. The transformation from hard size to soft size is distortion free and does not destroy the original hard size spectrum. The labZY-PSD application allows for instant exploration of different spectrum sizes with a single spectrum recording. This is a significant improvement in comparison to traditional spectrometers, 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 in 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 labZY-PSD application, in conjunction with nanoPSD hardware, 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-PSD application provides enhanced 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 percentage.

Installation

Windows 10
Windows 8
Windows 7
Windows Vista
Windows XP

The labZY-PSD application can be installed either from the supplied flash drive as part of the nanoPSD package or by downloading the installation file on www.labzy.com. To install the software from the flash drive, insert the flash drive into the computer's USB port. In the labZY-PSD directory find and execute setup.exe. To install the software from www.labzy.com, first download install_labZY-PSD_VERSION.zip and unzip or open it. The setup files and the labZY-PSD application are digitally signed by LABZY, LLC. It is recommended that an old version of the software be uninstalled before installing the new version of the labZY-PSDsoftware. To begin the installation execute the setup.exe file. Once the installation begins follow the instructions of the software installer as outlined below.

Step 1

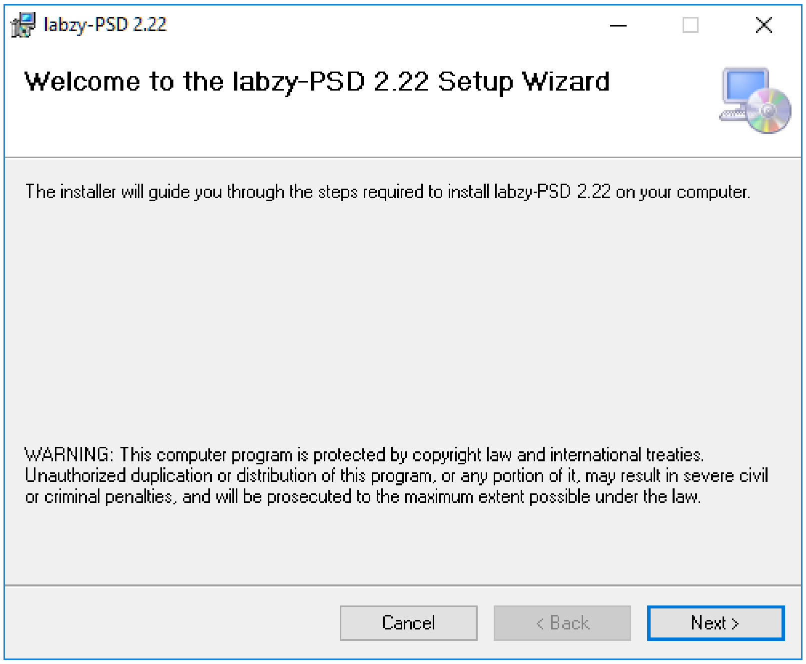


Figure 1.1. Welcome page of labZY-PSD Setup Wizard window.

Press “Next.”

Step 2

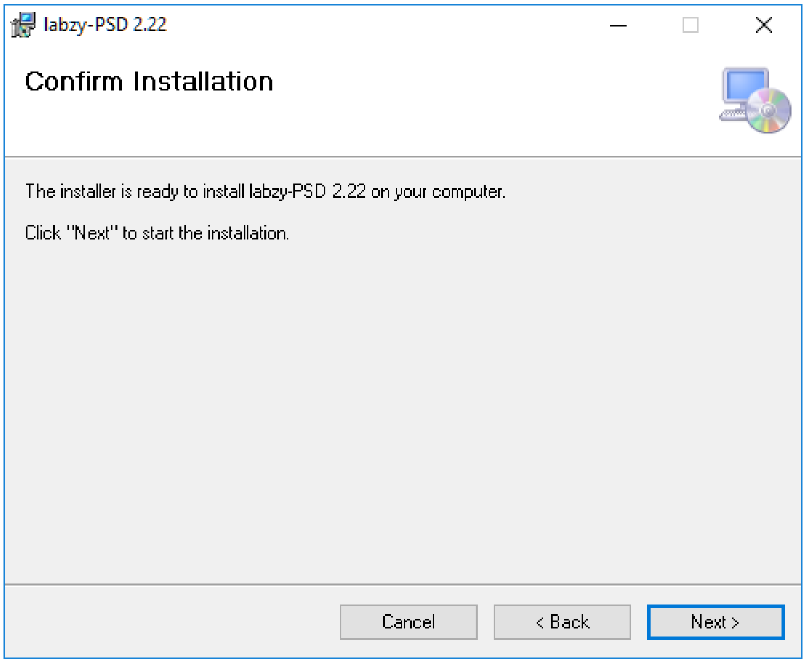


Figure 1.2 Confirm Installation page of labZY-PSD Setup Wizard window.

Press “Next.”

Step 3

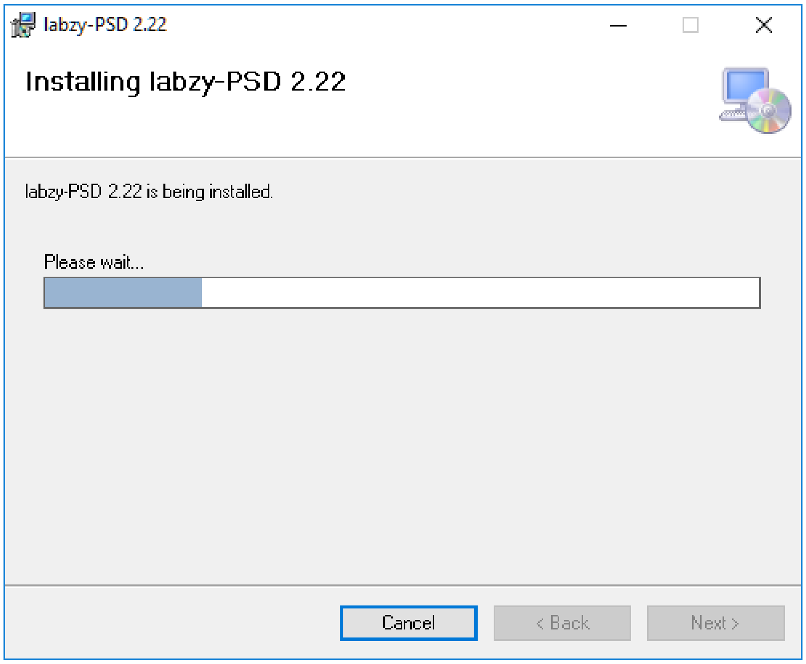


Figure 1.3. Wait for the installation to complete

Step 4

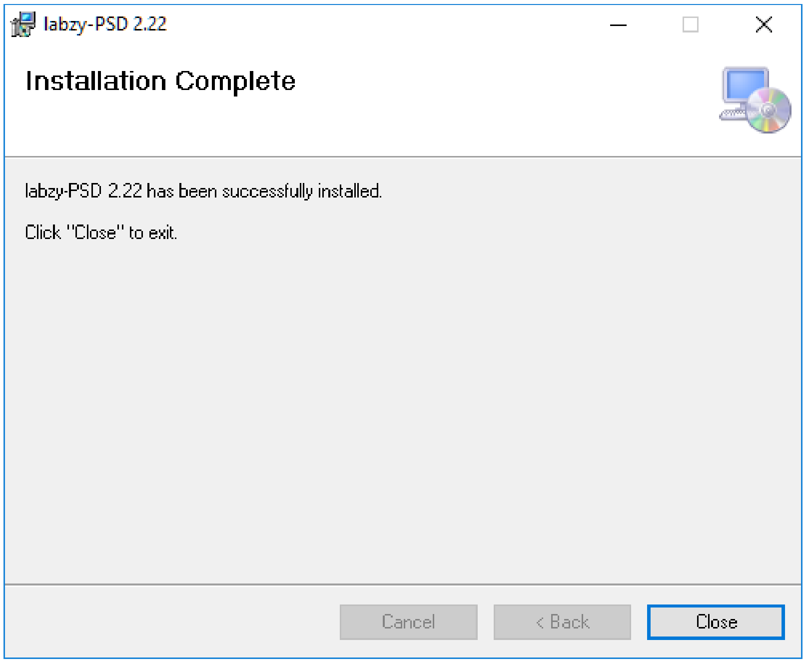


Figure 1.4. Installation Complete page of labZY-PSD Setup Wizard window.

Press “Close.”

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

Figure 1.5. labZY-PSD application icon.

A folder called labZY- PSD X.XX (X.XX is the version number) will be created in the start menu. This folder contains shortcuts to the labZY-PSD application and the utility to Uninstall labZY-PSD The labZY group is shown below.

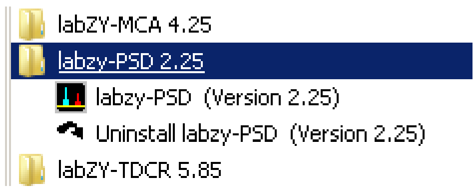


Figure 1.6. labZY group in Windows 7 and Windows XP.

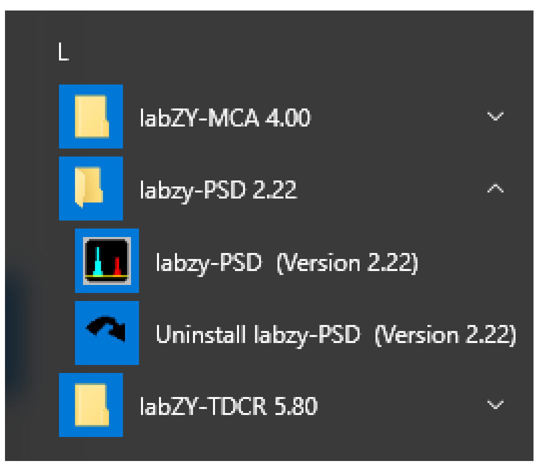


Figure 1.7. labZY group in Windows 10.

To uninstall the labZY-PSD application, execute the Uninstall labZY-PSD shortcut. If you need to reinstall or upgrade the labZY-PSD application, you must first run the Uninstall labZY-PSD utility.

Executing labZY-PSD

The labZY-PSD application 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 message (Figure 1.8) may appear

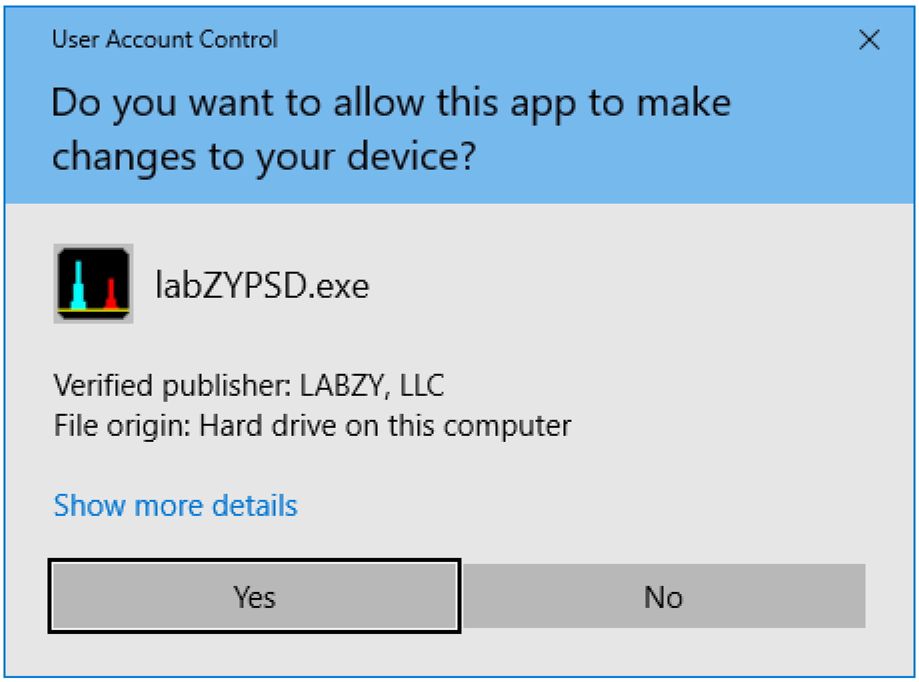


Figure 1.8. User Account Control - Verified Publisher: LABZY, LLC message.

Press “Yes” to allow the execution of the software.

The labZY-PSD application will open a window displaying the default layout of the application (Figure 1.9).

The labZY-PSD 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-PSD terminates, its current visual state, calibration and FOM data are stored and will be restored at the next run. No other information is preserved upon exiting the application.

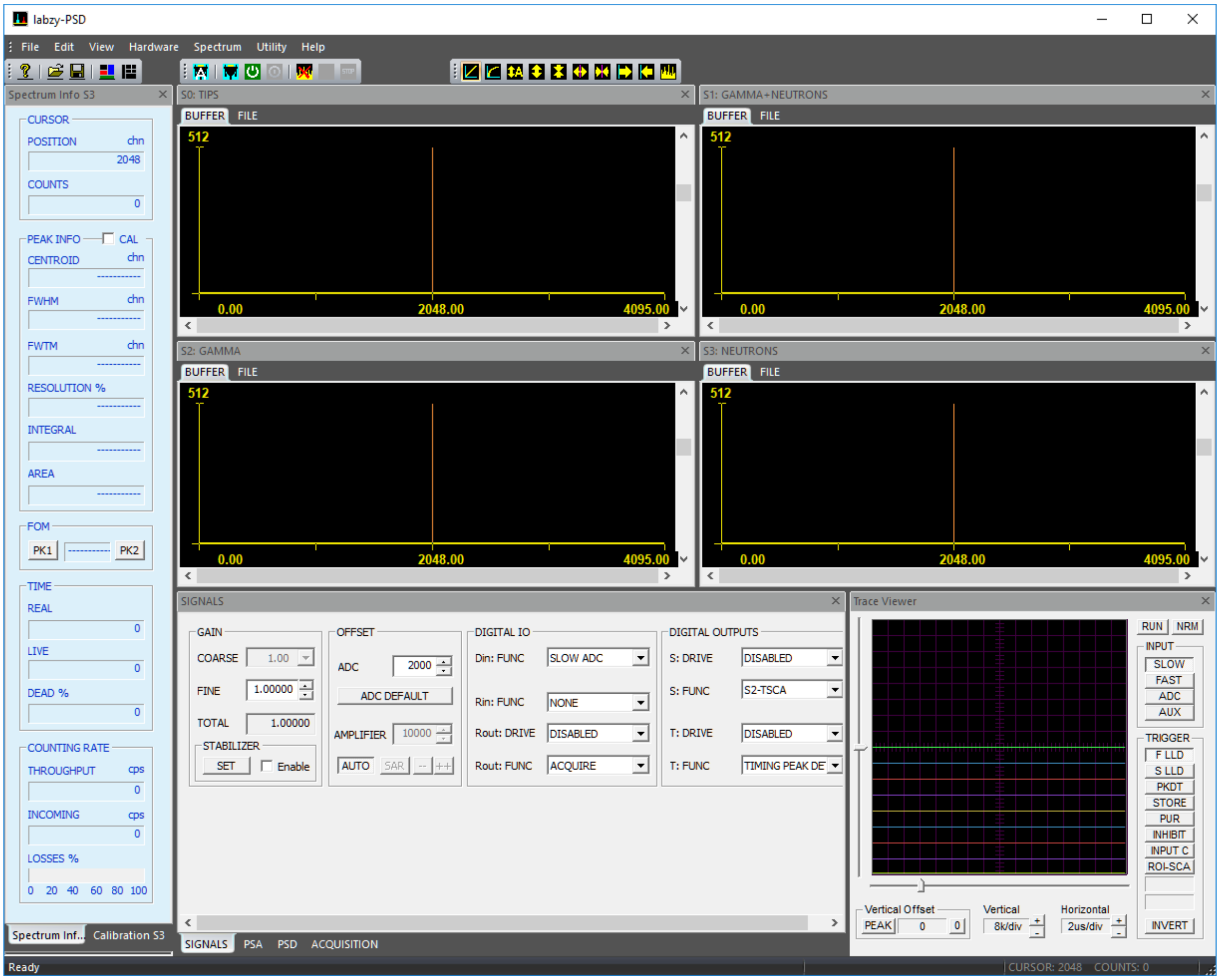


Figure 1.9. labZY-PSD default layout.

Basic Components

Menu

File

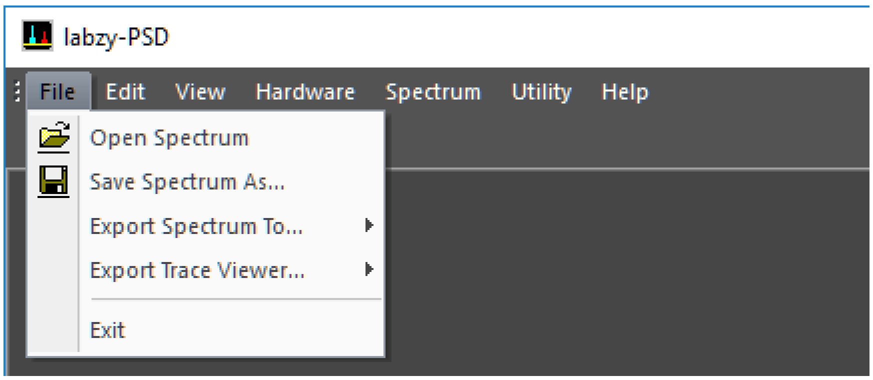


Figure 2.1.1. File menu.

The File menu can Open Spectrum files and Save Spectrum As… in a labZY-PSD file format with default extension *.lps*. Additionally, it can Export Spectra to other file formats such as CSV. The labZY-PSD file format (*.lps*) is described in Appendix A.

When saving and exporting a spectrum, a prompt is displayed to enter a Spectrum Tag.

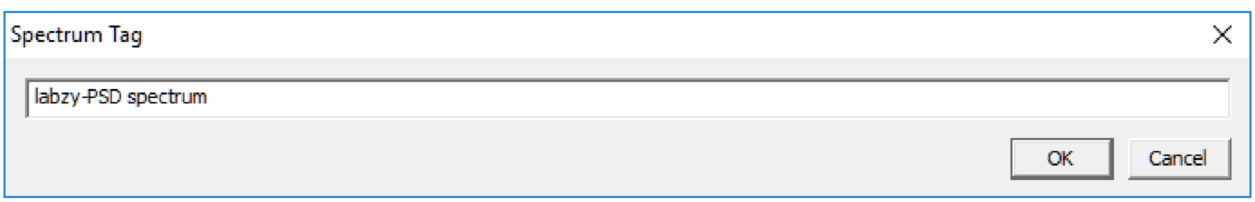


Figure 2.1.2. Spectrum Tag.

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-PSD file format also saves all of the hardware settings, along with the volatile data 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-PSD application is connected to nanoPSD. The ROI and calibration data are also stored in the labZY-PSD spectrum files.

The Open Spectrum command can only open spectra saved in a labZY-PSD file format with extension *.lps*. When a spectrum is openned, 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 a virtual hardware and not to the nanoPSD connected to the labZY-PSD 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.

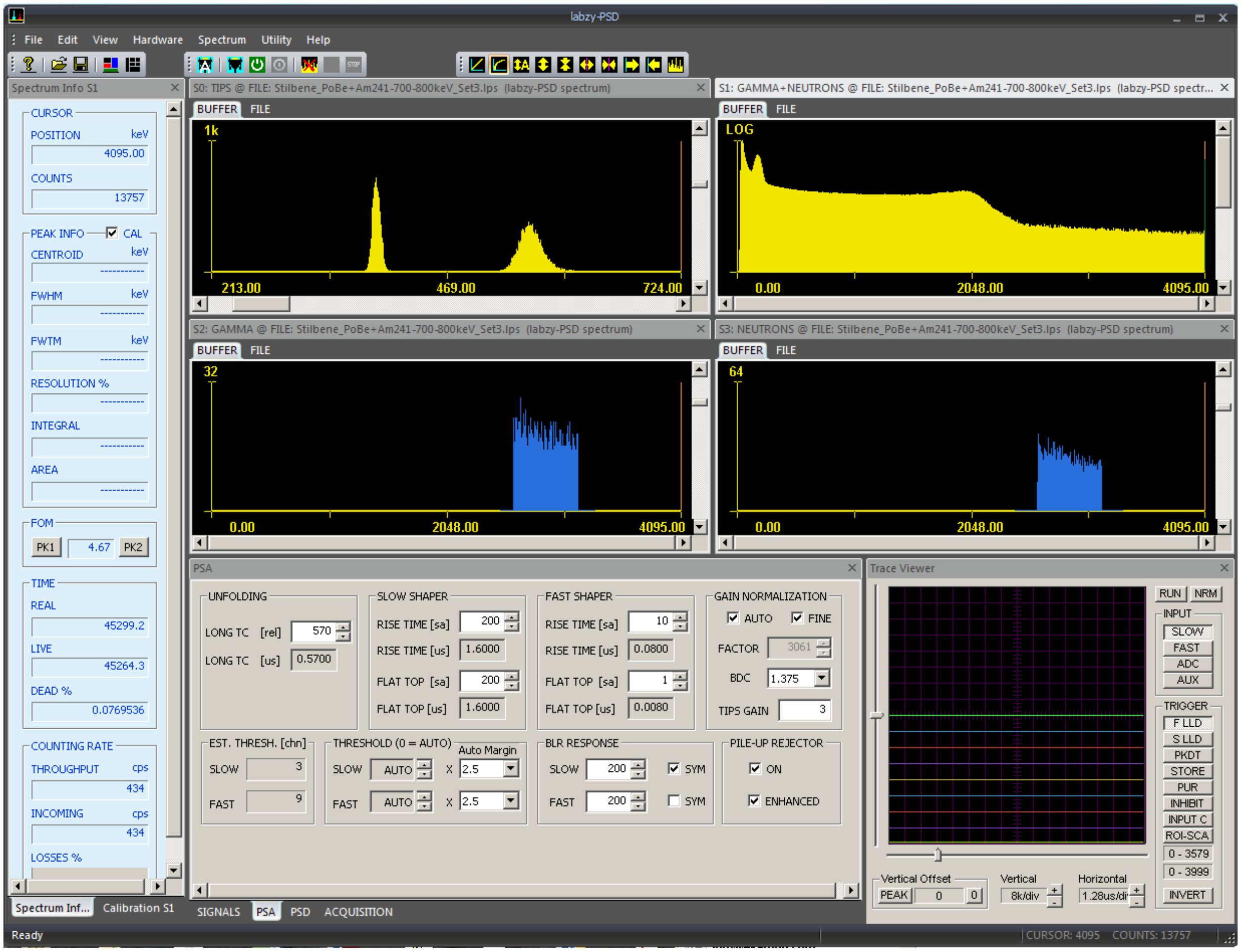


Figure 2.1.3. labZY-PSD sample spectra in default layout.

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. Note that exported spectra not in *.lps* format may not be opened by the labZY-PSD application.

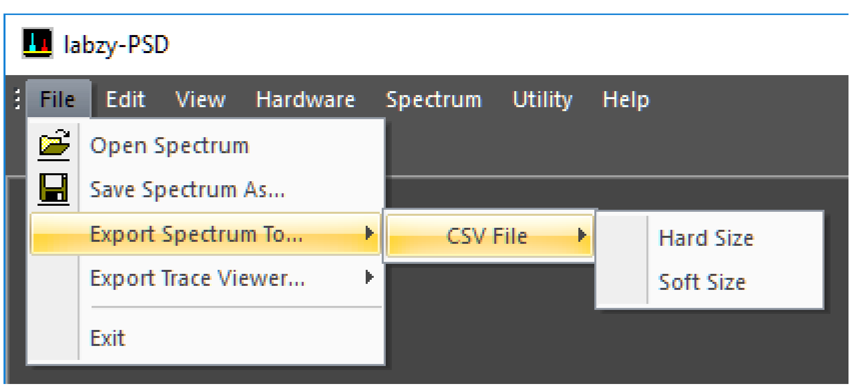


Figure 2.1.4. File menu → Export Spectrum To… → CSV File options.

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.

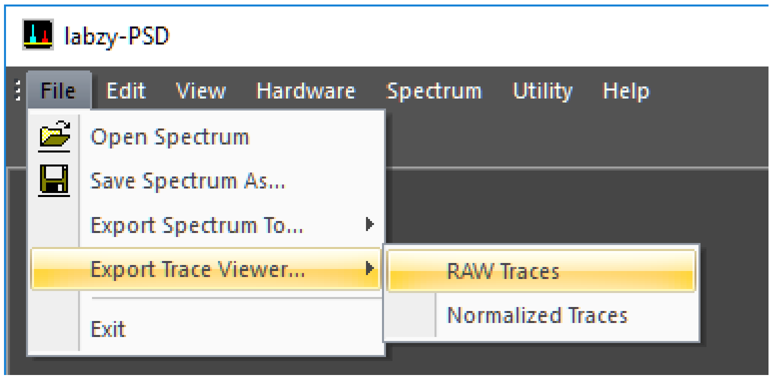


Figure 2.1.5. File menu → Export Trace Viewer… options.

Edit

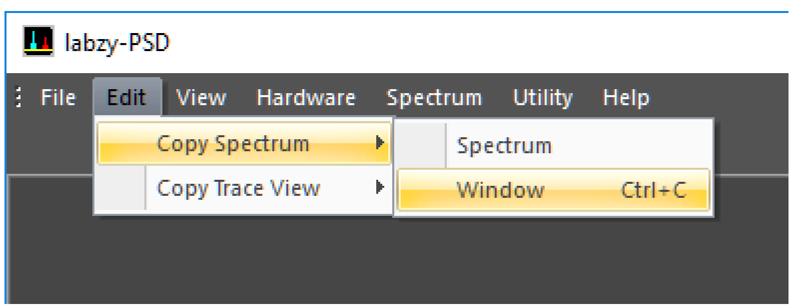
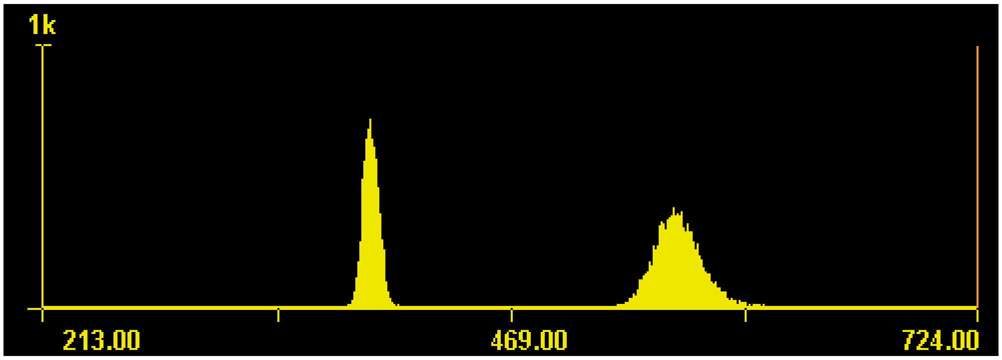


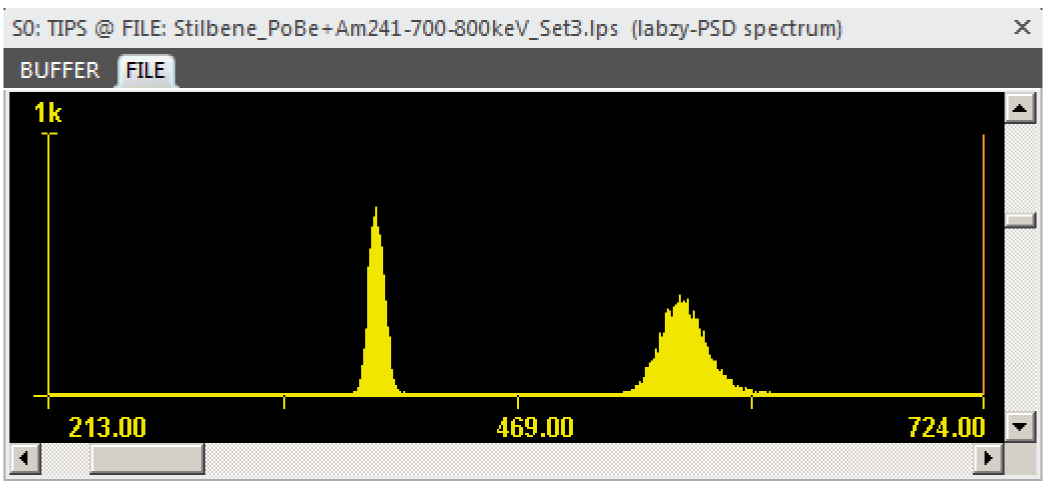
Figure 2.1.6. Edit menu → Copy Spectrum options.

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

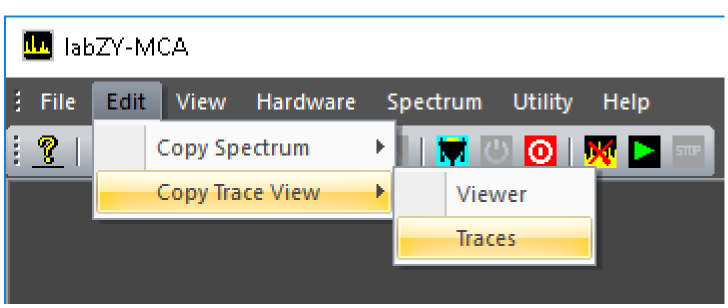
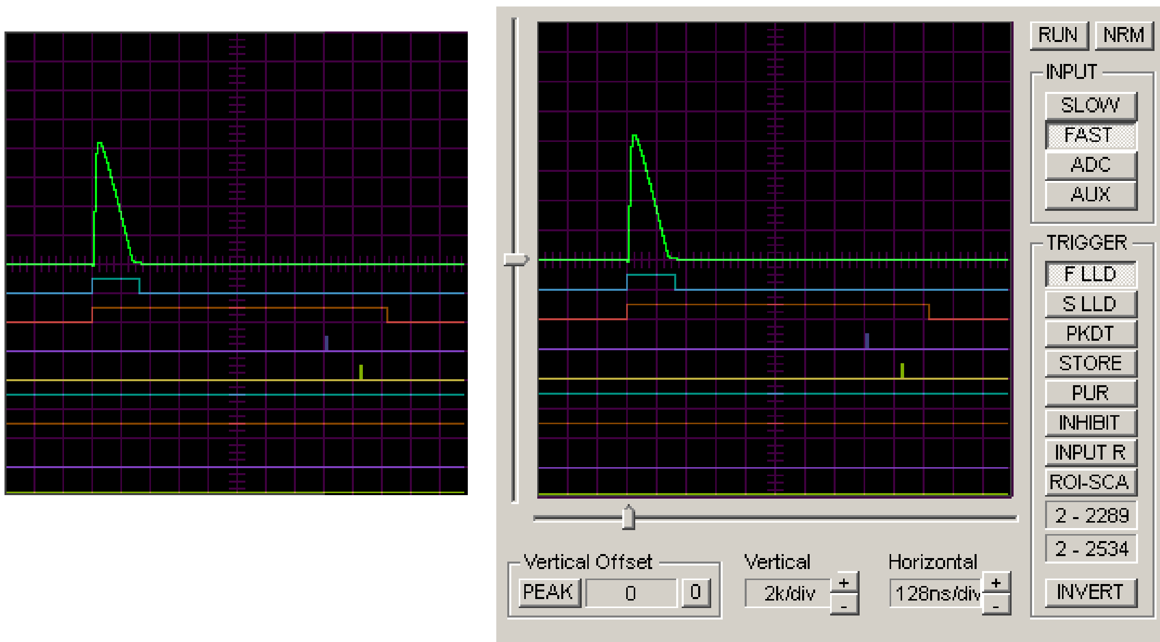


Figure 2.1.8. Edit menu → Copy Trace View options.

The Copy Trace View command 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. It is recommended that the Trace Viewer window is undocked to avoid interference with other windows.



a) b)

Figure 2.1.9. Clipboard Images: a) Copy Trace View → Traces; b) Copy Trace View → Viewer.

View

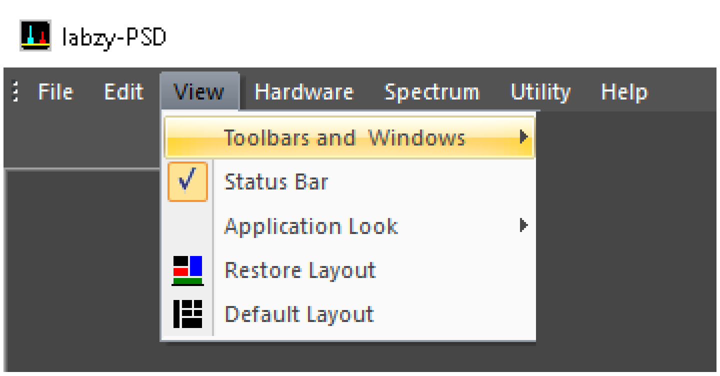


Figure 2.1.10. View menu.

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.

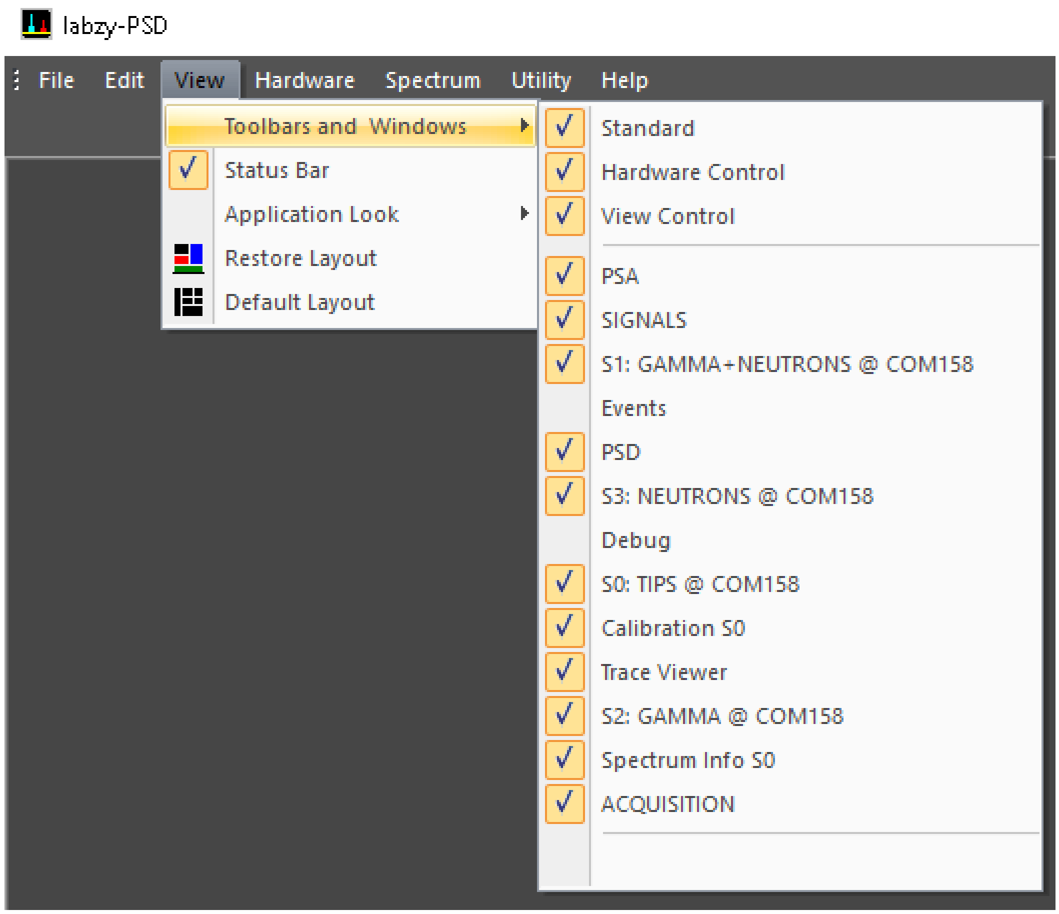


Figure 2.1.11. View menu → Toolbars and Windows options.

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.

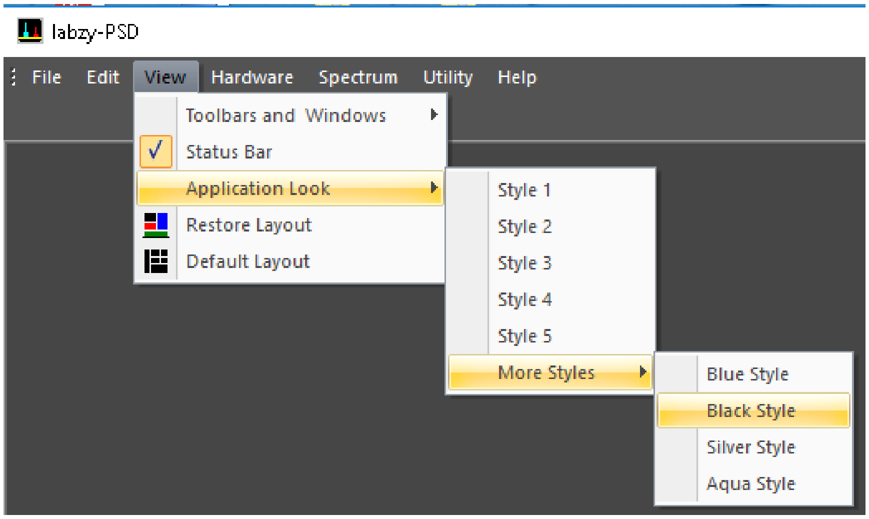


Figure 2.1.12. View menu → Application Look → More Styles.

Restore Layout restores the size, position, and other view attributes from when the application was last opened. This command is useful if the docking windows become hidden or scrambled. Note that at exit, labZY-PSD 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 the labZY-PSD installation.

Hardware

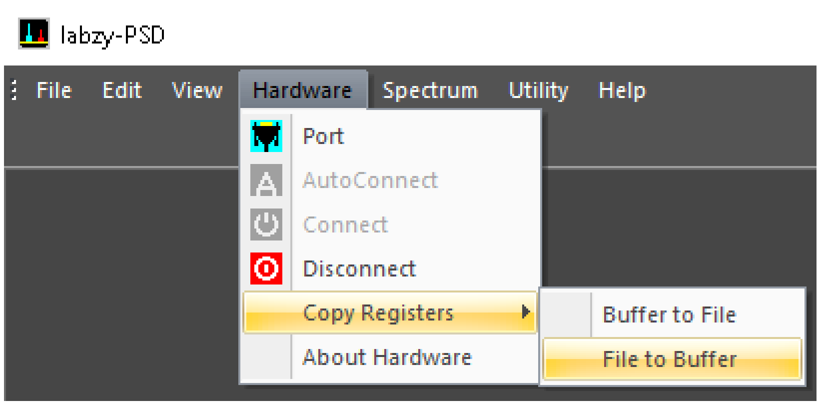


Figure 2.1.13. Hardware menu.

The Hardware menu has various controls related to the labZY hardware. The Port command allows the user to choose a computer communication port (COM port) to which the nanoPSD device is connected. This command may also be used to identify the port to which a nanoPSD device is connected. The port identification can only be performed for USB ports. To identify the port, start the labZY-PSD application and disconnect the nanoPSD device of interest from the computer. Execute the Port command from the menu. A port dialog will open.

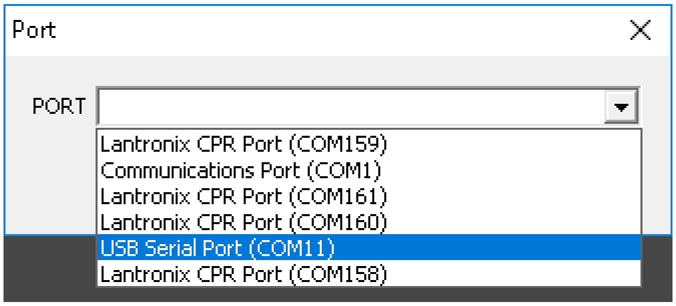


Figure 2.1.14. Available ports (Hardware > Port).

Take note of the drop-down list of available ports. Close the port selection. Connect the nanoPSD to an available USB port. Wait until the USB driver installs. Reopen 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 labZY device is identified, select the relevant port and close the dialog by pressing “OK.”

Once the port has been identified and selected, the labZY-PSD 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 nanoPSD devices and connect to them. It is strongly recommended that the AutoConnect command is used to connect automatically to nanoPSD devices.

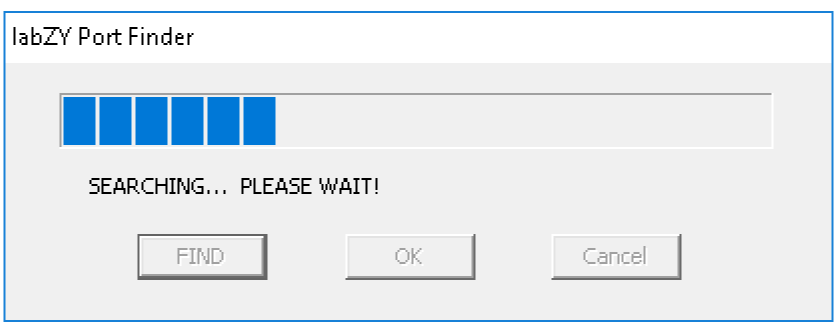


Figure 2.1.15. labZY Port Finder window during a search.

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 of more times. If no ports are found after few attempts, a hardware connection and/or driver installation troubleshooting must be performed. The Disconnect command will disconnect the labZY-PSD 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 labZY device. 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 labZY device, first establish a connection between the device and the labZY-PSD application. 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.

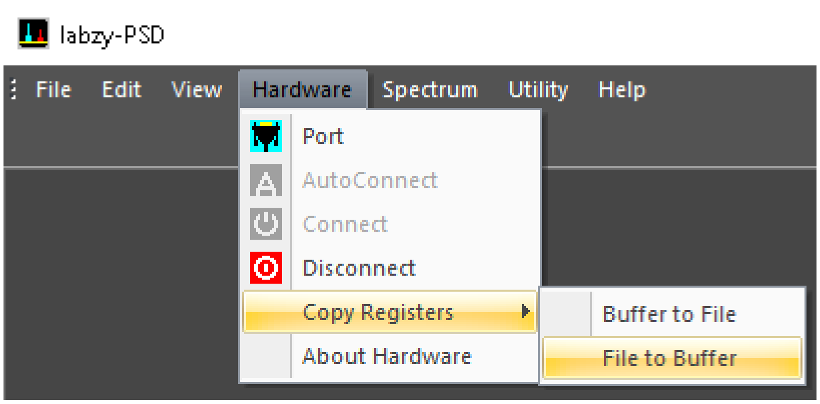


Figure 2.1.16. Hardware menu → Copy Registers options.

The Copy Registers → Buffer to File command can be used for a temporary storage of hardware settings while the labZY-PSD 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 labZY device is connected, the About Hardware command 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.

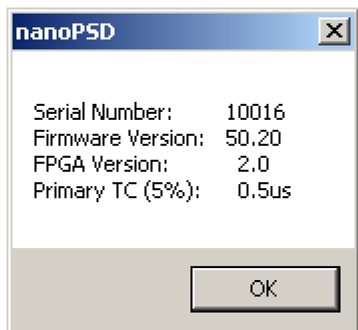


Figure 2.1.17. About hardware.

Spectrum

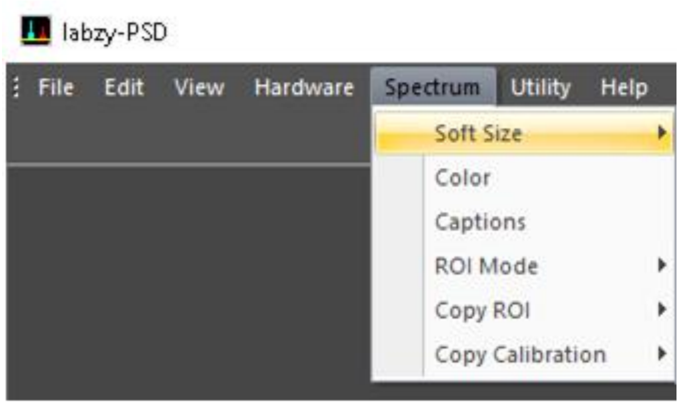


Figure 2.1.18. Spectrum menu.

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.

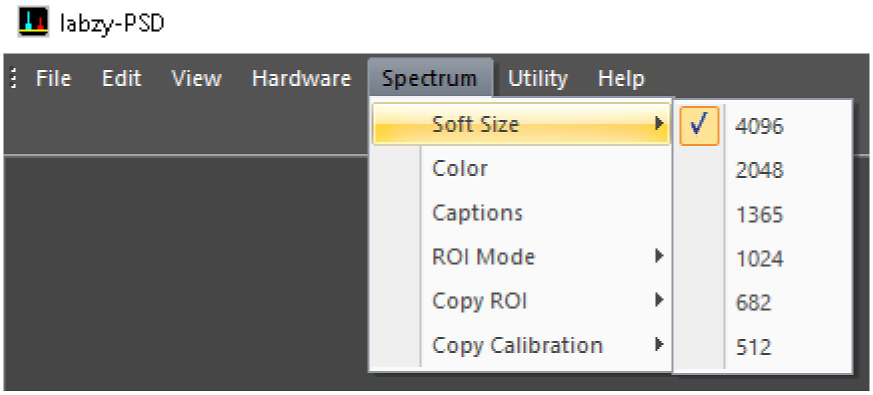


Figure 2.1.19. Spectrum menu → Soft Size options.

The Soft Size selection applies to the spectrum visible in the Spectrum Window. When switching between different soft sizes, the ROI and the calibration coefficients are also adjusted accordingly.

The Color command invokes a dialog to adjust the colors used to display the spectrum and associated features. The color can be adjusted individually for each spectrum window S0 to S3 or common collor settings for all spectrum windows. 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-PSD application and will be automatically restored at the consecutive execution of the software.

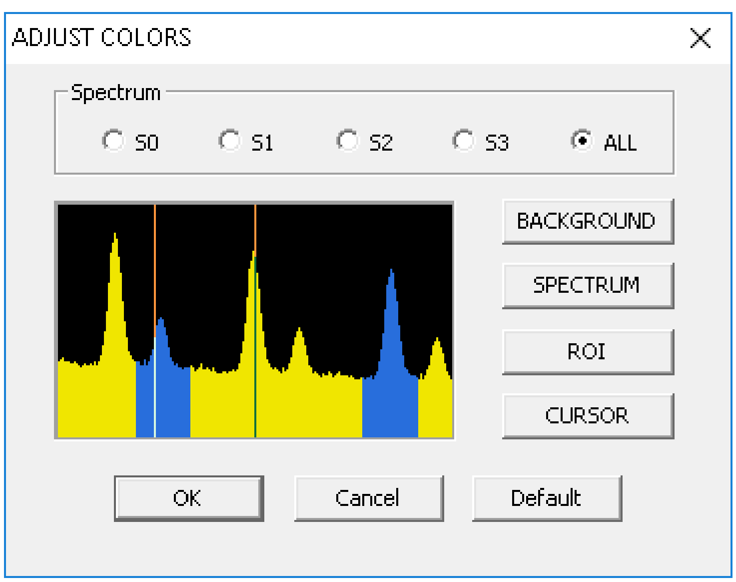


Figure 2.1.20. Adjust Colors Dialog.

The Captions command will open a dialog to enter spectral window captions. The Captions are stored upon exiting the labZY-MCA and will be automatically restored at next execution of the software.

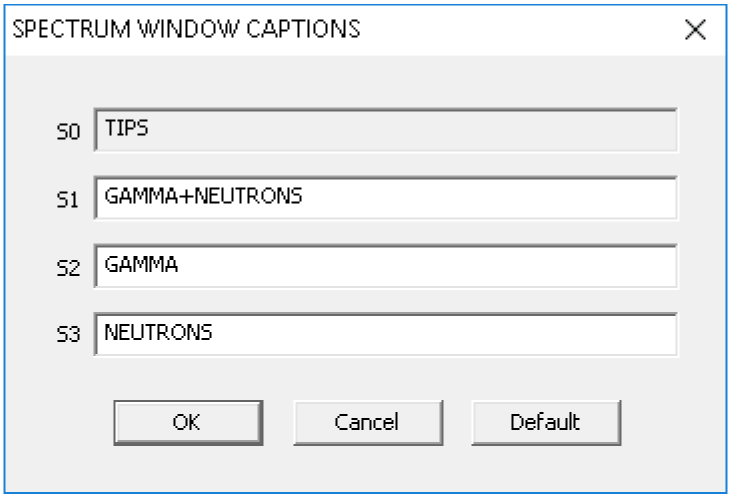


Figure 2.1.21. Widow Captions Dialog.

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.

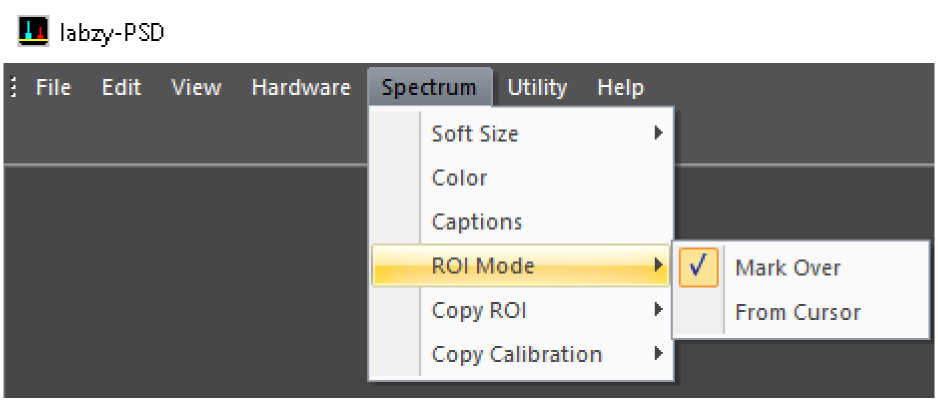


Figure 2.1.22. Spectrum menu → ROI Mode options.

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.

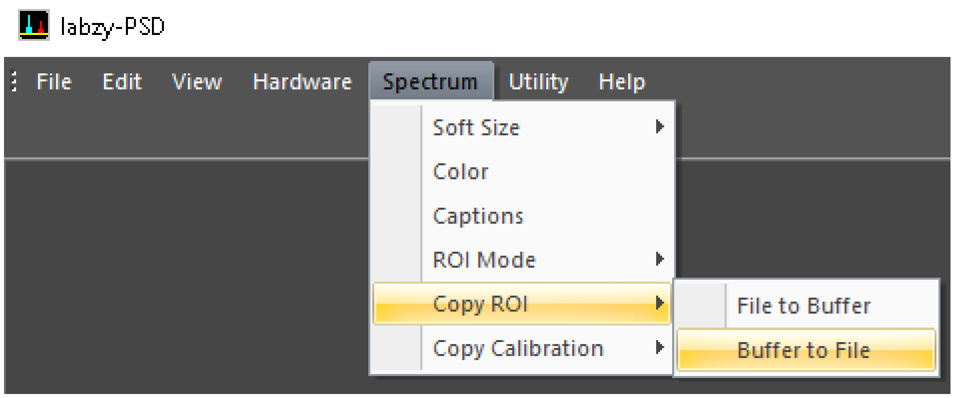


Figure 2.1.23. Spectrum menu → Copy ROI options.

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.

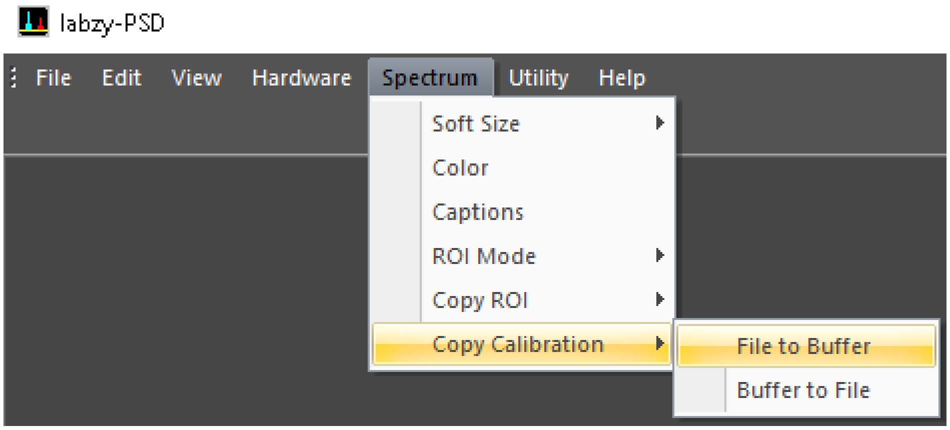


Figure 2.1.24. Spectrum menu → Copy Calibration options.

Utility

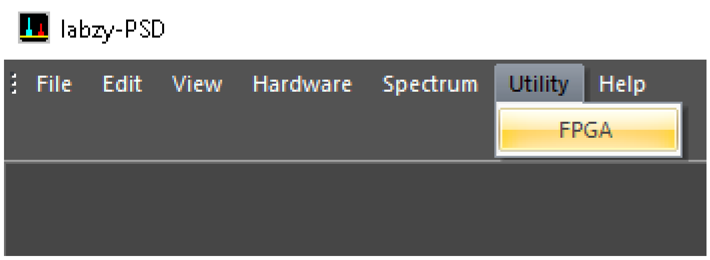


Figure 2.1.25. Utility menu.

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

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

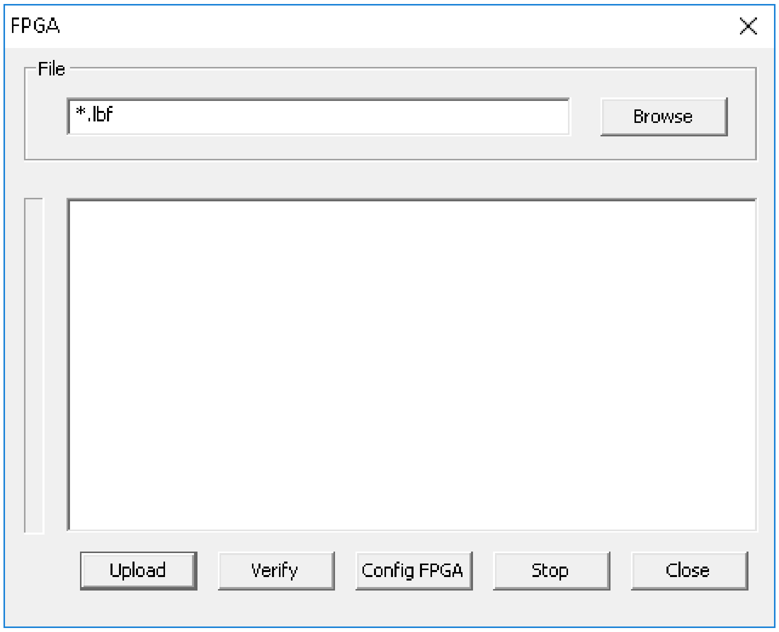


Figure 2.1.26. The **FPGA** dialog.

To upload an FPGA design, execute the following steps:

1) Press the "**Browse"** button 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.

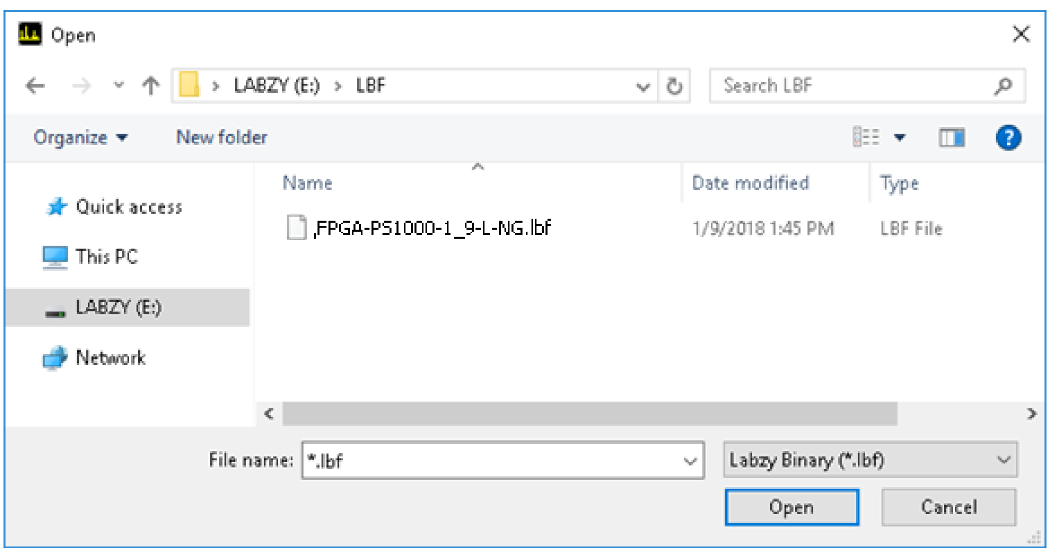


Figure 2.1.27. The Open dialog to select **FPGA** design file.

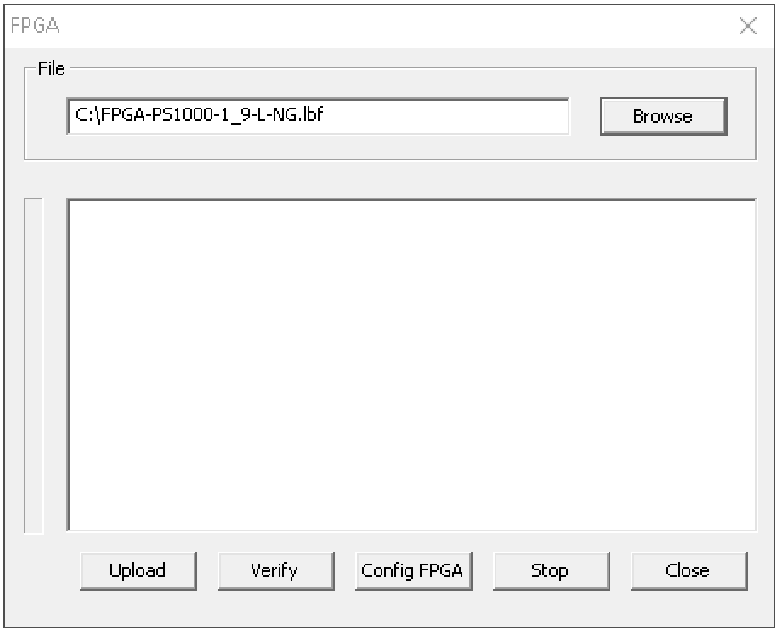


Figure 2.1.28. The **FPGA** dialog ready for uploading the design file.

2) Press "**Upload**" and wait up to 2-3 minutes until the design programming file is uploaded. If the upload fails repeat this step.

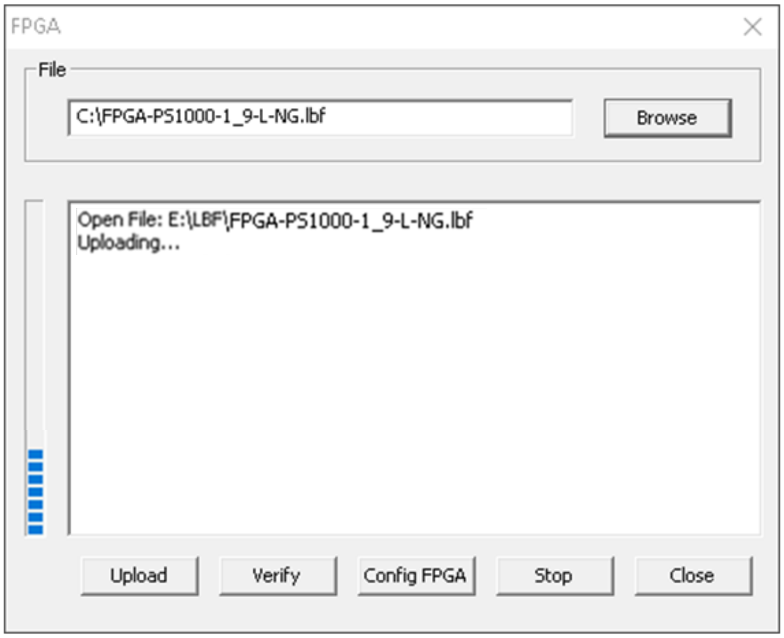


Figure 2.1.29. The Upload progress indicator.

3) For the uploaded FPGA design to take effect either cycle the power of the labZY device or press the "**Config FPGA**" button. 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.

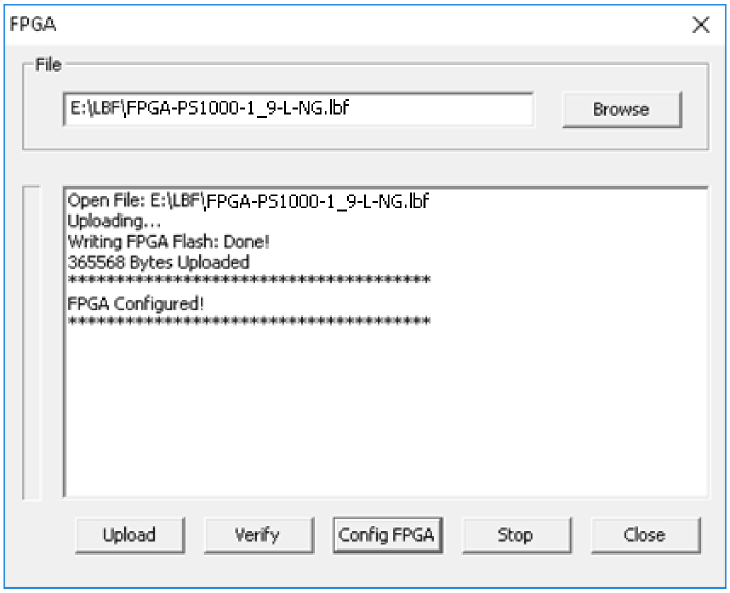


Figure 2.1.30. The upload of the FPGA design and the configuration of the FPGA are complete.

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

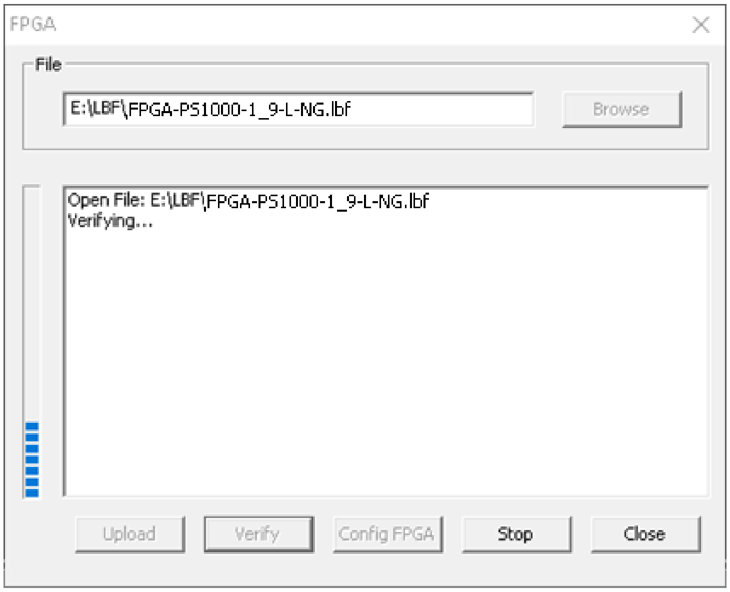


Figure 2.1.31. FPGA design and verification.

Help

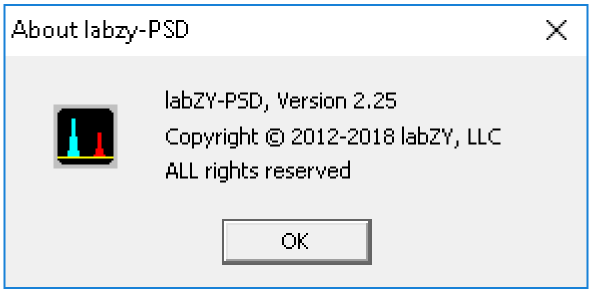


Figure 2.1.32. About labZY-PSD.

The Help menu provides version information about the labZY-PSD application. 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-PSD application are contained within docking windows. Docking windows are not permanently attached to the frame of the labZY-PSD 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-PSD 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 Windows

There are four spectrum windows with designation S0, S1, S2, and S3. The spectra in the four spectrum windows are recorded simultaneously. The Spectrum Windows have two tabs. The first tab is the Buffer tab. When the Buffer tab is selected, the spectrum from connected hardware device is displayed in the window. Selecting a tab in one of the S0-3 windows causes selection of the same tab in all spectrum windows.The content of the Buffer window is automatically updated by the nanoPSD 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 in the selected spectrum window.

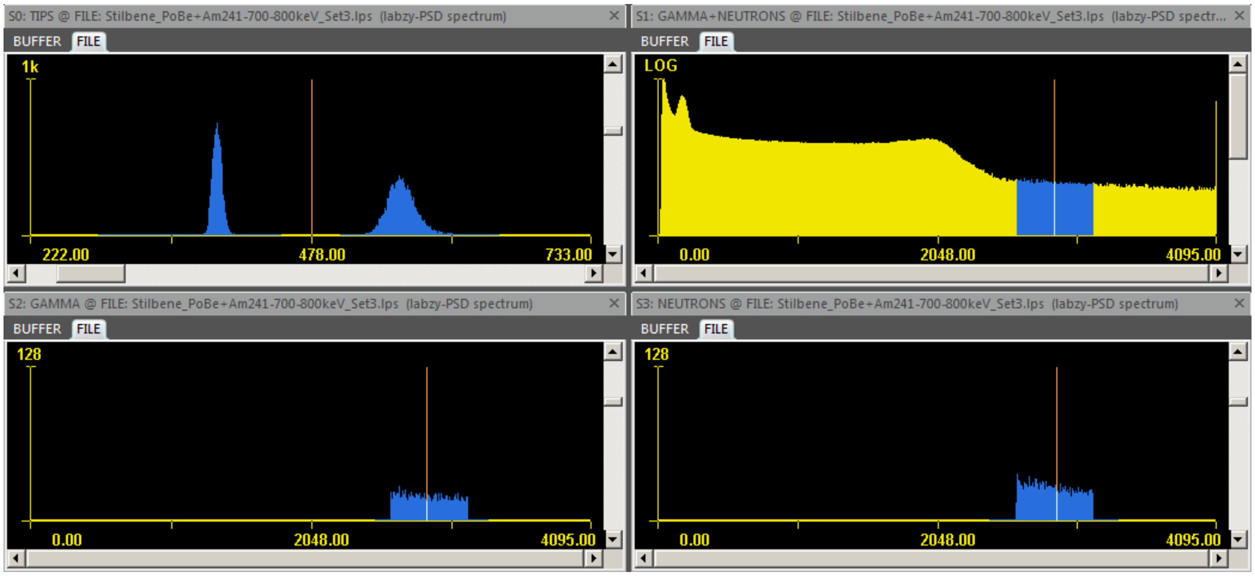


Figure 2.2.1. Sample display of the four Spectrum Windows.

Spectrum Window S0

The Spectrum Window S0 always records TIPS spectra. The TIPS spectra are signature spectra of the pulse shape associated with measured radiation. In a typical neutron-gamma pulse-shape analysis the gamma peaks have centroids that are position at lower channels than the centroids of the neutrons. TIPS spectrum is similar for alpha-betta pulse-shape analysis - betta peak centroid is on the left of the alpha peak centroid.

Spectrum Window S1 to S3

The Spectrum Windows S1 to S3 record pulse-height spectra. The spectra in these windows can be selectively recorded based on pulse-shape discrimination. S1 and S2 can also use be recorded using pulse-height discrimination simultaneously with the pulse-shape discrimination. The discrimination criteria are established using TIPS ROIs and PHA ROIs which are set in the PSD Window. S1 is typically used to record the raw pulse-height spectrum and its TIPS ROIs are set to accept all pulse-shapes. It is possible in some cases to set S1 in pulse-shape discriminating mode. S2 and S3 are used to record the pulse-shape discriminated PHA spectra with simultaneous pulse-height and pulse-shape discrimination.

PSA Window

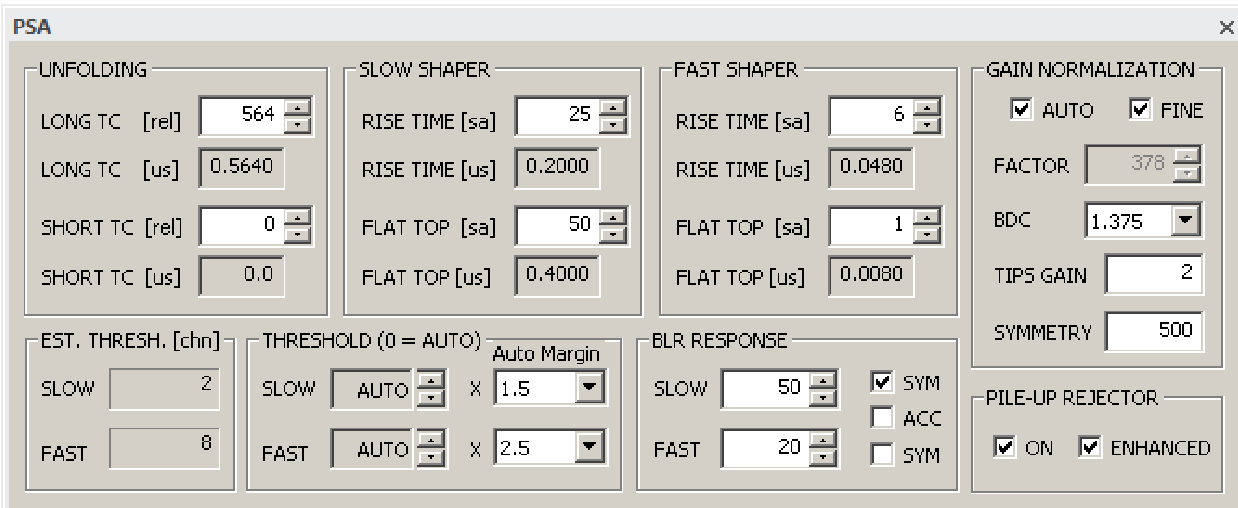


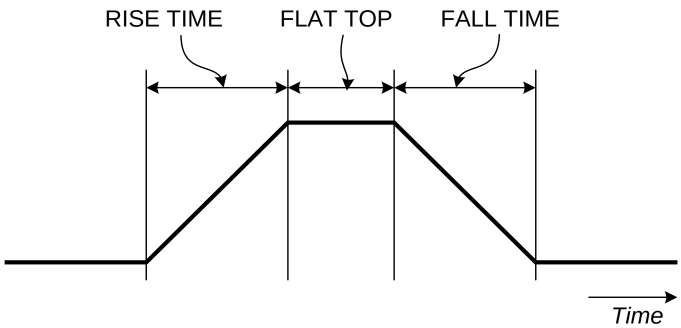
Figure 2.2.2. PSA Window.

The PSA Window contains various controls that are related to the Digital Pulse-Shape Analyzer (PSA). Using these controls, the appropriate registers of the nanoPSD can be modified. Upon connection of the nanoPSD to labZY-PSD application, the fields of the controls are updated with the values from the device’s hardware. Changing the fields while the nanoPSD is connected will also change the corresponding nanoPSD registers.

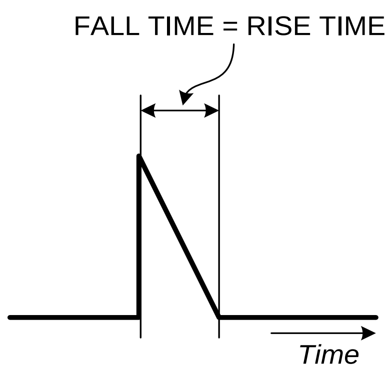
The nanoPSD FPGA designs implement multiple digital shapers. Two of these shapers can be adjusted by the user using the labZY-PSD application. These shapers are designated as Slow and Fast. The Slow shaper synthesizes trapezoidal pulses while the Fast shaper synthesizes inverse sawtooth pulse. The Slow Shaper is the main spectroscopy shaper. The pulse-height of the Slow Shaper pulses is used to record the pulse-height spectra. Note that the nanoPSD can be used as a general purpose spectrometer using scintillation detectors such as NaI(Tl), LaBr etc.

Both Slow and Fast shapers are also used in the determination of TIPS. It is importnat that both shapers are set correctly or optimal TIPS and pulse-height spectrum acquisition. There are two groups in the PSA Window that are used to set the shaper parameters.

The controls in the group SLOW SHAPER allows adjustment of the Rise Time and the Flat Top of the Slow Shaper. Rise Time of this shaper should be adjusted to optimize the signal-to-noise ratio. For plastic and liquid scintillators the default value of the RiseTime is 25 (200ns). The Flat Top is adjustment affects the TIPS spectrum. For short Flat Tops the separation of the neutron-gamma (alpha-betta) peaks is reduced. A longer flat top may increase the TIPS peak separation but may lead to a higher sensitivity to PMT after pulses, undetected (below the threshold) pile-up and other after-pulse effects. The suggested values of the Flat Top are 25(200ns) for fast counting, 100(800ns) for counting-FOM balance, 225(1800ns) for low counting rate and higher FOM.



a)



b)

Figure 2.2.3. a) SLOW SHAPER - Trapezoidal Pulse; FALL TIME = RISE TIME;

b) FAST SHAPER - Inverse Sawtooth Pulse; 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 as normalization parameter for TIPS. The Rise Time of the fast shaper is in fact the fall time of the inverse sawtooth pulse. A Rise Time is typically set between 5 (40ns) and 20 (160ns).

For standard nanoPSD FPGA designs the flat top of the fast shaper is fixed to 1 (8ns). In such case any attempt to change the flat top will be rejected.

Both slow and fast shapers are equipped with low level noise discriminators (LLD). The noise discriminator produces an active logic signal when the shaped signal is above a noise threshold. The group THRESHOLD contains the controls to set the noise discriminator thresholds. The thresholds for the slow shaper noise discriminator (SLOW LLD) and the fast shaper noise discriminator (FAST LLD) can be set manually by the edit controls SLOW and FAST respectively. Entering zero in these controls will set the noise thresholds in Automatic mode (AUTO). The AUTO mode is independently set for SLOW LLD and FAST LLD. It is recommended to use AUTO mode for both shapers. However, in some cases, a pickup of high frequency or fast rising signals may trigger the fast discriminator in AUTO mode causing increased dead time. In such a case, the threshold should be adjusted manually until the pick-up signals are rejected by the FAST LLD. 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 Gaussian probability density function of the noise distribution. The threshold estimation is shown in the group EST. THRESH., which are read only controls.

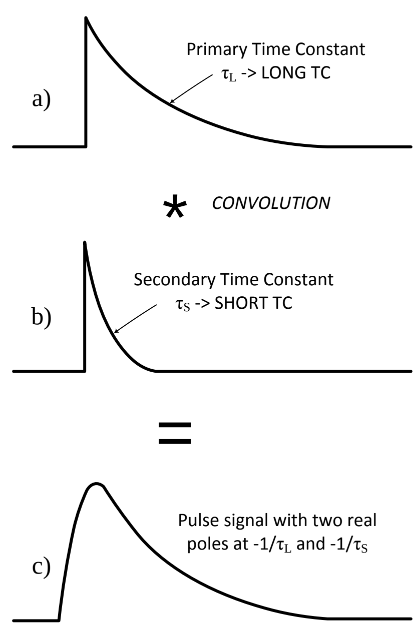


Figure 2.2.4. A pulse signal is characterized by LONG TC and SHORT TC.

The PSA of nanoPSD 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 PSA pulse shapers have two functional stages. The first stage unfolds the input pulses by removing the two exponential responses corresponding to the two real poles of the signal. That is, the result of the unfolding function is an unit impulse. The unit impulse is fed to the second stage which performs a synthesis of trapezoidal/triangular pulse shapes.

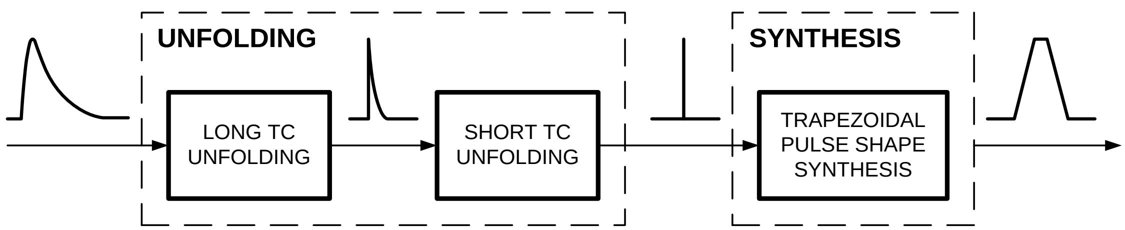


Figure 2.2.5. Unfolding to synthesis.

The expected optimal LONG TC of the nanoPSD is between 500ns and 600ns.. The SHORT TC normally depends on the response of the amplifiers in the amplification chain including the rise time response of the nanoPSD preamplifier. The SHORT TC may also represent the decay time constant of scintillation detectors.

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. A slow shaper Rise Time of 1μs is recommended to adjust the LONG TC. SHORT TC, if available, should be adjusted observing the pulses from the fast shaper.

The group UNFOLDING provides means for adjustment of the LONG TC and the SHORT TC. The nanoPSD devices are delivered with LONG TC already adjusted to match the time constant of the internal preamplifier. The SHORT TC adjustment of nanoPSD is normally disabled and any attempt for adjustment will be ignored.

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 requires a normalization of the pulse-height of the digitally synthesized trapezoidal pulse shapes.

The group GAIN NORMALIZATION presents control for automatic and manual adjustment of the gain 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 plastic and liquid scintillators the BDC is between 1 and 1.375. Setting BDC to 1 is always a safe choice. However, for optimum utilization of the ADC range the BDC can be fine trimmed using the Trace Viewer. The adjustment procedure is described in Appendix B.

TIPS GAIN control is used to digitally adjust the gain of the TIPS spectrum. The range is from 1 to 500. However, the gain may be automatically reduced and the setting ignored when the setting is incompatible with the nanoPSD shaper settings. Typical values for the TIPS GAIN are in the range 2 to 5.

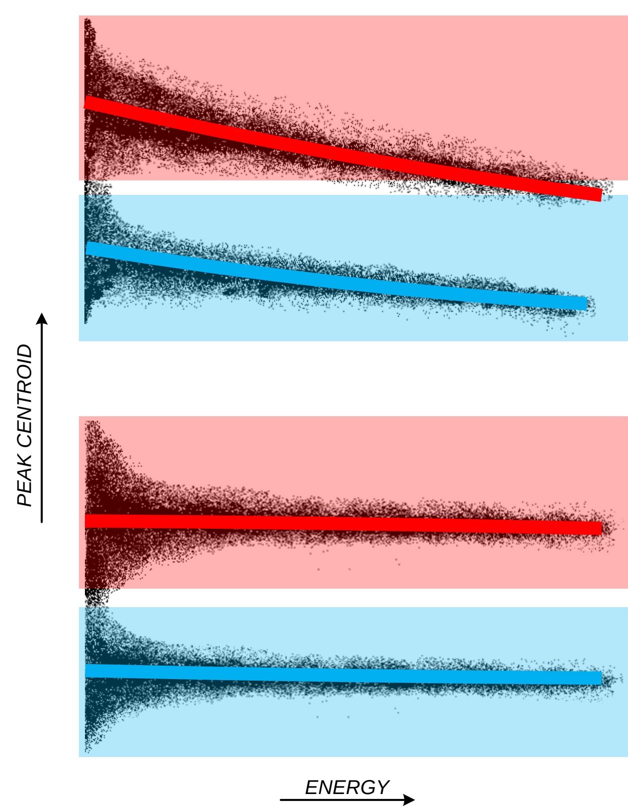
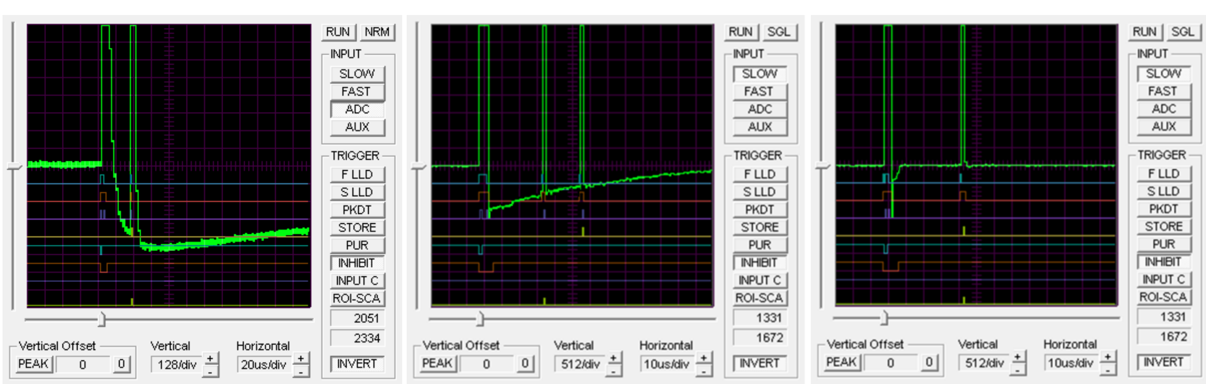


Figure 2.2.6. Illustration of the effect of the SYMMETRY parameter. Top: SYMMETRY = 0, Bottom: SYMMETRY > 0. Red and blue lines illustrate the centroid of the TIPS peaks.

Due to nonlinearities in detector response (scintillator + PMT) often the centroids of the TIPS peaks change position as function of the energy as illustrated in Figure 2.2.6, top image. To correct for this nonlinearity the SYMMETRY parameter can be used. The SYMMETRY parameter can take values from -10000 to +10000. However, typical values are between -1000 and +1000. Setting SYMMETRY to zero is the safe way to start using nanoPSD and labZY-PSD. Symmetry should be set positive if the low energy peak centroids are shifted towards higher TIPS channels compared to the centroids at higher energies as shownin Figure 2.2.6. Typical values of SYMMETRYfor nanoPSD connected to a stilbene scintillator is 0 ±100..

The BLR RESPONSE group controls the BLR of the SLOW and FAST shapers. The response of the BLR is inversely proportional to the value set for SLOW or FAST. A smaller number means more aggressive BLR. For moderate counting rates the BLR response should be in the range of 200 to 400. For higher counting rates the range is 20 to 200. The symmetric mode (SYM) of the BLR is recommended for the SLOW shaper. Depending on the counting rates and the undershoots of the detector signals the SYM mode will require a careful evaluation to determine whether or not to use it.

The ACC mode of the BLR is a special mode when AC coupled detectors have non-linear response and cause severe undershoot when recovering from overload condition. This situation is rare and in most cases ACC will be left unchecked. When ACC is checked the BLR operates in fast recovery mode when overload caused by the detector signals is detected - the INHIBIT signal becomes active LOW. Fig. 2.2.7 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 2.2.7. 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, an independent **pulse-shape analysis** of the fast pulse shape is performed (Figure 2.2.8). The pile-up rejection capability of the nanoPSD 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.

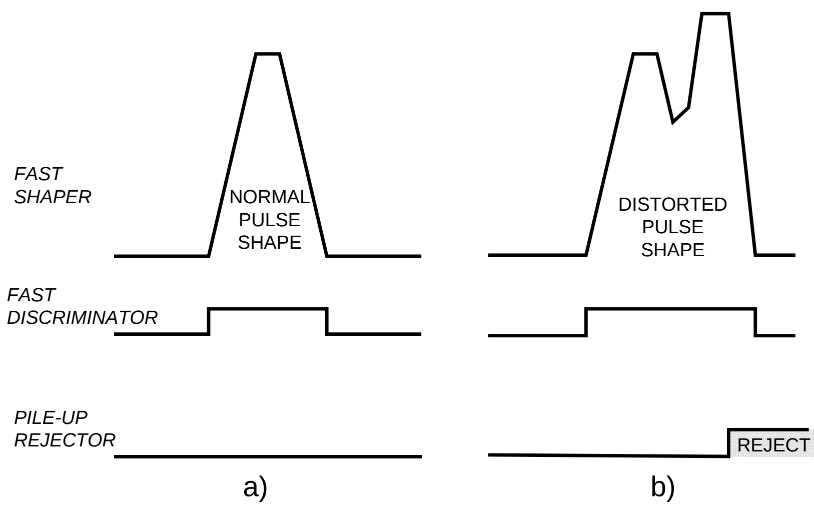
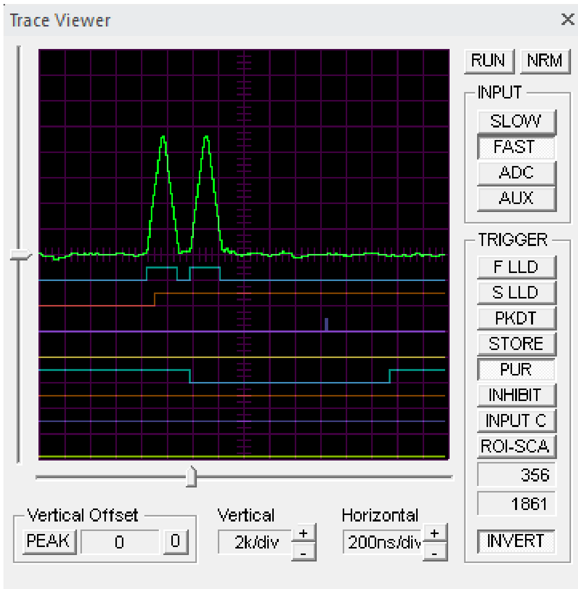
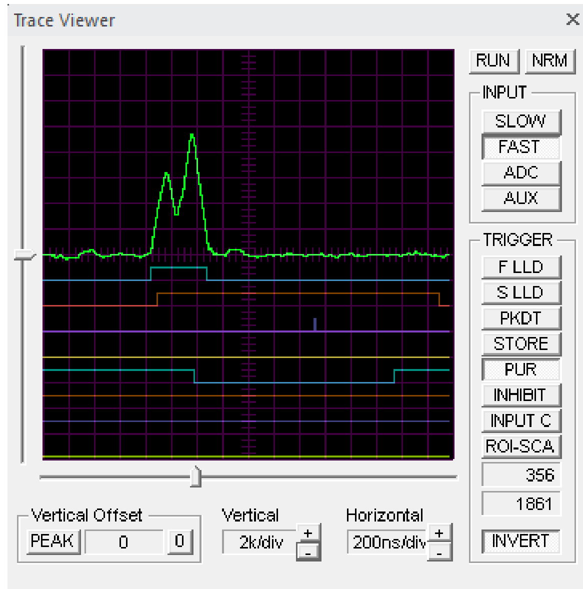


Figure 2.2.8. a) Pile-up free fast shaper/discriminator; b) fast shaper pile-up and pulse-shape distortion.

Figure 2.2.9 shows 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.



a)



b)

Figure 2.2.9. a) Traditional pile-up rejection; b) enhanced pile-up rejection.

SIGNALS Window

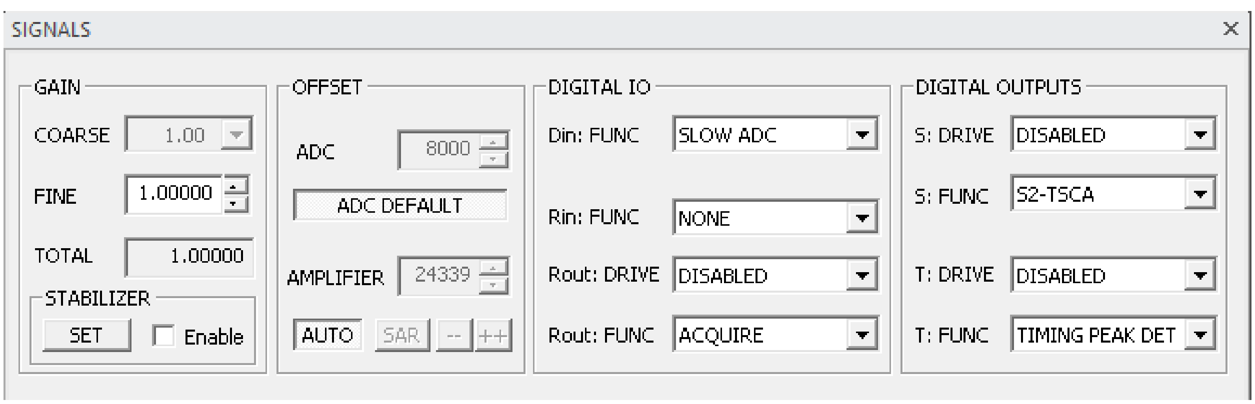


Figure 2.2.10. SIGNALS Window.

The SIGNALS Window contain the controls of the analog signals, analog signals related functions and configuration of the logic signals functions of the nanoPSD.

The DIGITAL IO group contains controls for the digital Inputs and digital IO functionality.

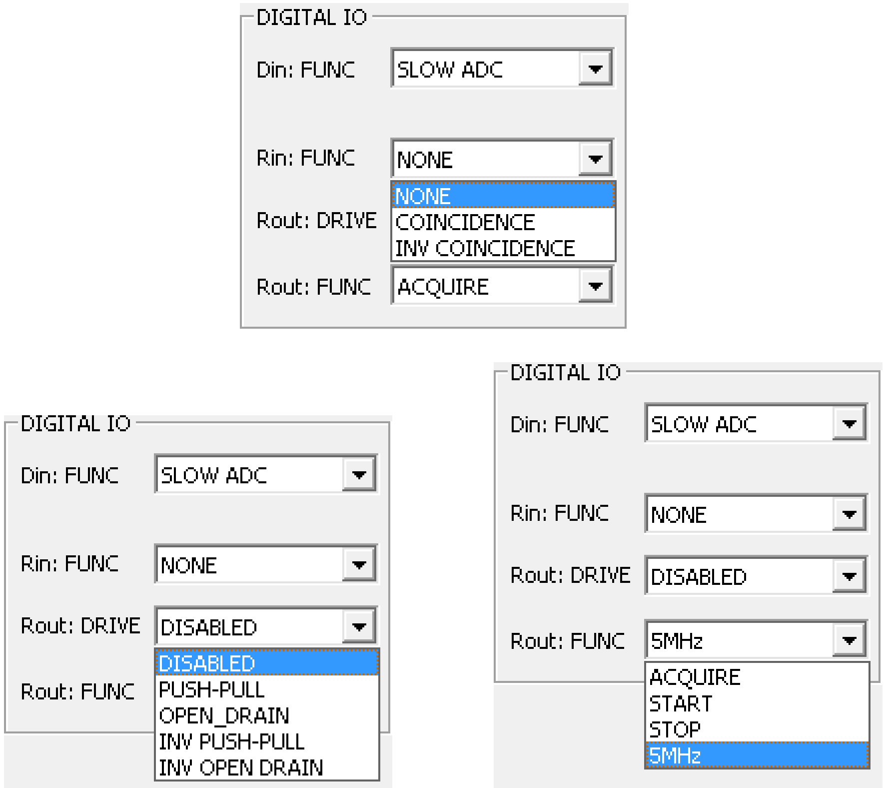


Figure 2.2.11. DIGITAL Inputs and IO options.

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 nanoPSD 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. 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 nanoPSD.

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

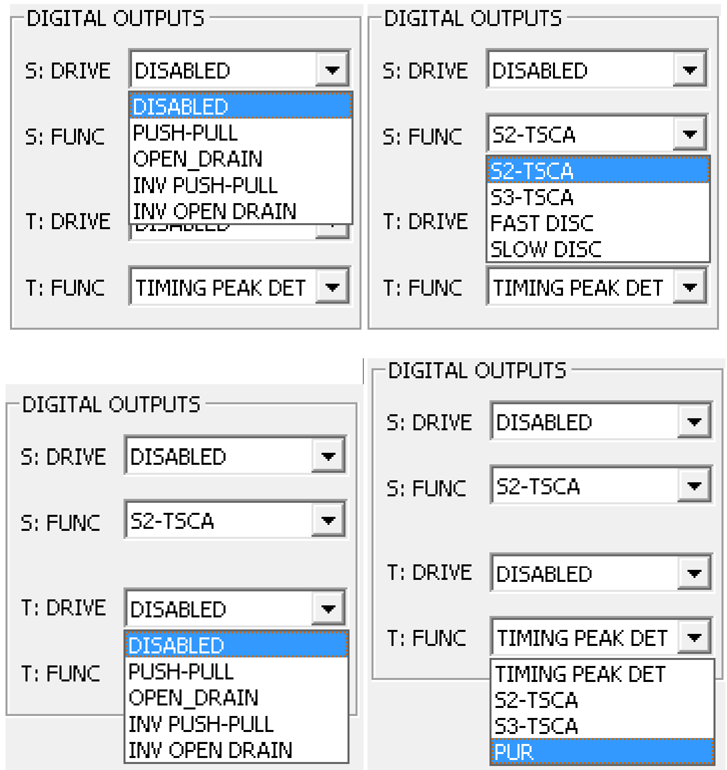


Figure 2.2.12. DIGITAL OUTPUTS configuration options.

The OFFSET group relates to, and is of extreme importance for the operation of the ADC and PSA. 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 by the ADC OFFSET.

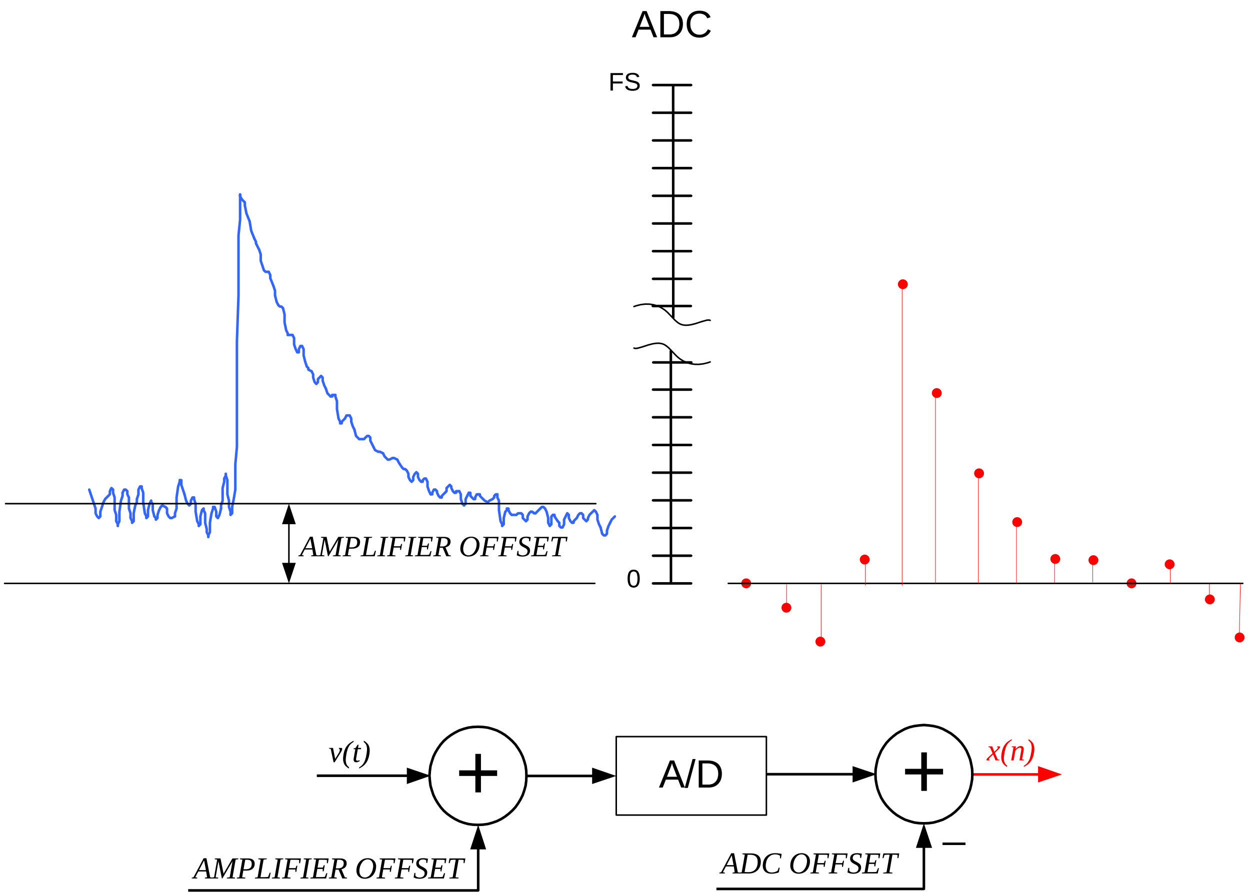


Figure 2.2.13. Offset cancellation.

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

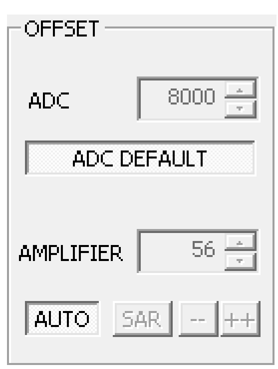


Figure 2.2.14. Offset group.

Some measurements) 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 quickly pressing the AUTO button twice. 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 COARSE of nanoPSD is fixed to **ONE** (1). 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. The preferred FINE GAIN is one (1) which minimizes the analog amplification noise. The read-only TOTAL field reports the total analog gain by multiplying the fine gain and the coarse gain.

The STABILIZER group allows for setting and controlling the gain stabilizer of the nanoPSD. The STABILIZER should only be used with spectra with distinctive peaks. **For pulse-shape discrimination applications the STABILIZER should be DISABLED.** The stabilizer adjusts the fine gain of the device. Therefore, in order to use the stabilizer the fin gain must be set at the middle of its scale - 1.10. The stabilizer offer maximum of 10% correction of the gain. Normally, the stabilizer is used with scintillation detectors which are sensitive to temperature variations. the stabilizer uses a reference peak from the acquired spectrum. For best results the centroid position of the peak must be greater than half of the spectrum scale. Pressing the SET button will open a dialog.

To automatically set the parameters of the stabilizer mark in S1 an ROI around the desired peak for stabilization and press the long button to generate recommended settings. You may also manually enter the peak parameters. To start the stabilization check the Enable box. It is important to let the stabilizer run for some time before starting an acquisition. The stabilizer is implemented in hardware and its operation is independent of the labZY-PSD application.

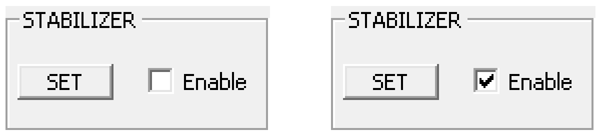


Figure 2.2.15. Stabilizer controls.

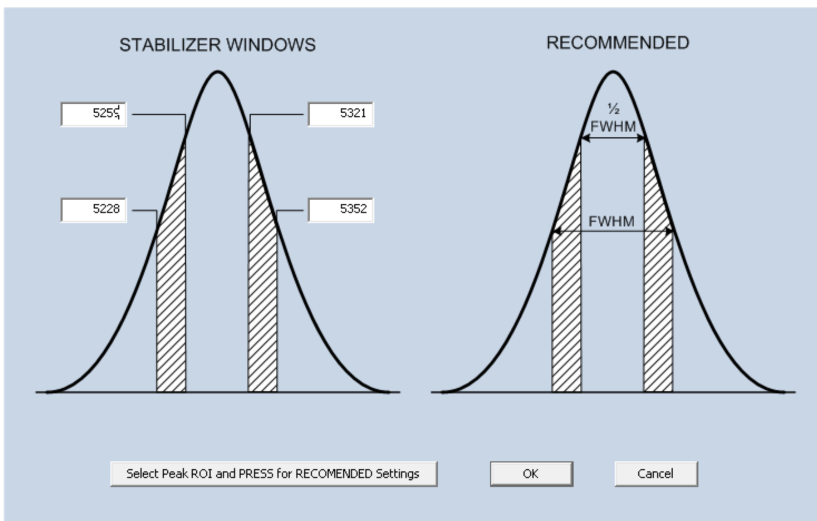


Figure 2.2.16. Stabilizer Setup Dialog.

PSD Window

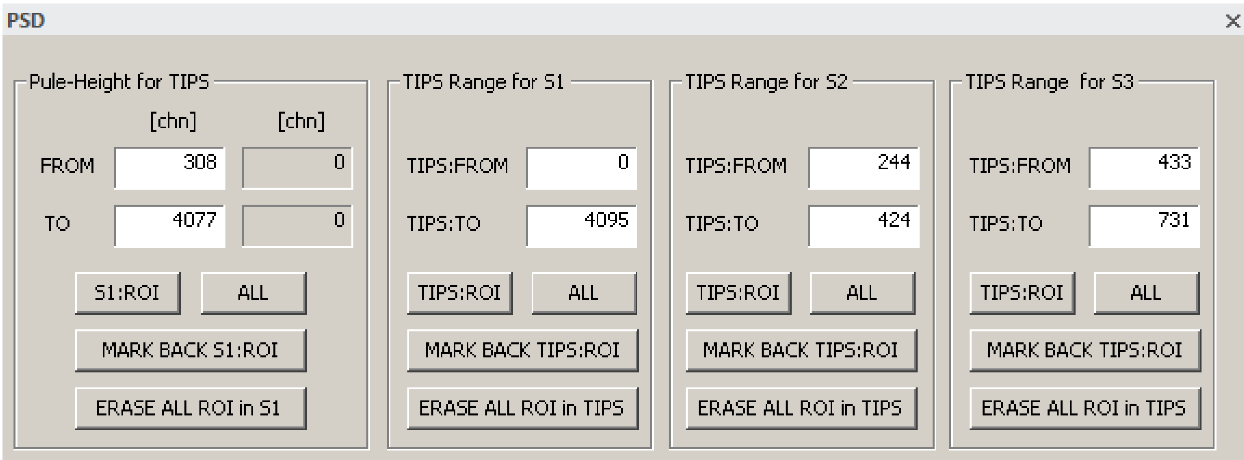


Figure 2.2.17. PSD Window.

The PSD window has controls that are used to specify the spectrum acquisition in the Spectrum Windows S0 to S3. It is important to note that a single event from the detector can be recorded in one or more Spectrum Windows or the event may be ignored and not recorded in any of the Spectrum Windows. Therefore, it is very important to understand the spectrum acquisition as defined by the controls of the PSD Window.

Fig. 2.2.18 shows the flowchart of the spectrum acquisition in S0 to S3. The only events being recorded are events that result in slow shaper amplitudes exceeding the Slow Thresh. and a fast shaper amplitude exceeding the Fast Thresh.. In other words for a detector event to be recorded both fast and slow low level discriminators (LLD) must be triggered. In addition events can be rejected if the Pile-Up rejector is enabled.

If an event passes all of the criteria above the Pules Height of the slow shaper (PH) and the TIPS value are found and captured. Based on the settings in the PSD Window groups S0 to S3 are selectively incremented.

There are four groups in the PSD Window. The first group "S1:ROI for TIPS" is used to control the data acquisition of the S0:TIPS spectrum window. In this group an ROI of the S1 spectrum window is entered. The purpose of this ROI is to specify a range of pulse-heights (PH) of the slow shaper which is the main spectroscopy shaper.

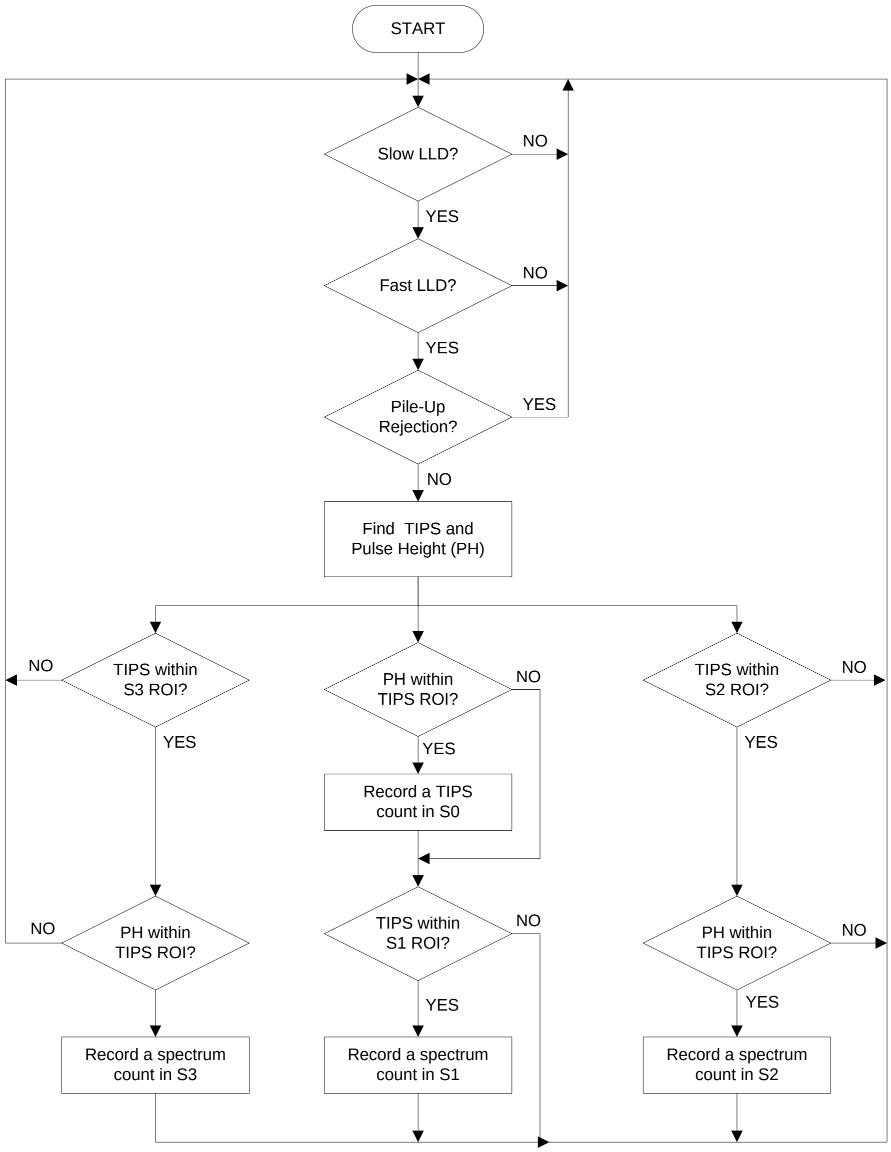


Figure 2.2.18. Flowchart of the spectrum acquisition in S0 to S3.

To enter the ROI select a region of interest in the S1 window. Place the cursor within the selected ROI and press the ROI button in the group to record the ROI in channels [chn]. If the spectrum in S1 window is calibrated and its calibration is enabled the ROI will also be displayed in calibration units, e.g. [keV]. If the nanoPSD is connected the ROI values will be stored in the hardware non-volatile memory and will be recalled every time the labZY-MCA software connects to the nanoPSD. The values of the ROI will be kept in the hardware even if the nanoPSD is turned off. Once the ROI is recorded in the "S1:ROI for TIPS" the ROI in S1 can be deleted, modified or new multiple ROIs can be created for the purpose of calibration or analysis.

The range of "S1:ROI for TIPS"   ROI determines the slow shaper pulse-height (energy) range that will be used to increment the spectrum of S0:TIPS. Pulses with amplitudes outside this range will be ignored and will not contribute to the S0:TIPS spectrum. By selecting multiple small regions of interest one can record a series of TIPS spectra to estimate the FOM as function of the energy. The all button will set an ROI that accepts al pulse-heights, effectively disabling the Pulse-Height discrimination for S0:TIPS. The MARCK BACK button allows marking back the ROI in S1 window. This is an useful feature when restarting the software or when the ROI has been deleted.

The remaining 3 groups in the PSD accept ROIs in a similar fashion as the first group. The ROIs in these group are from the S0:TIPS spectrum window and are only displayed in channels [chn]. The group "TIPS:ROI for S1" determines the range TIPS values for S1 by entering an ROI marked in the TIPS spectrum or by pressing the ALL button. Normally the ALL is pressed which eliminates the pulse-shape discrimination for S1. This allow to record the full ,above the threshold pulse-height, (energy) spectrum in S1.

.

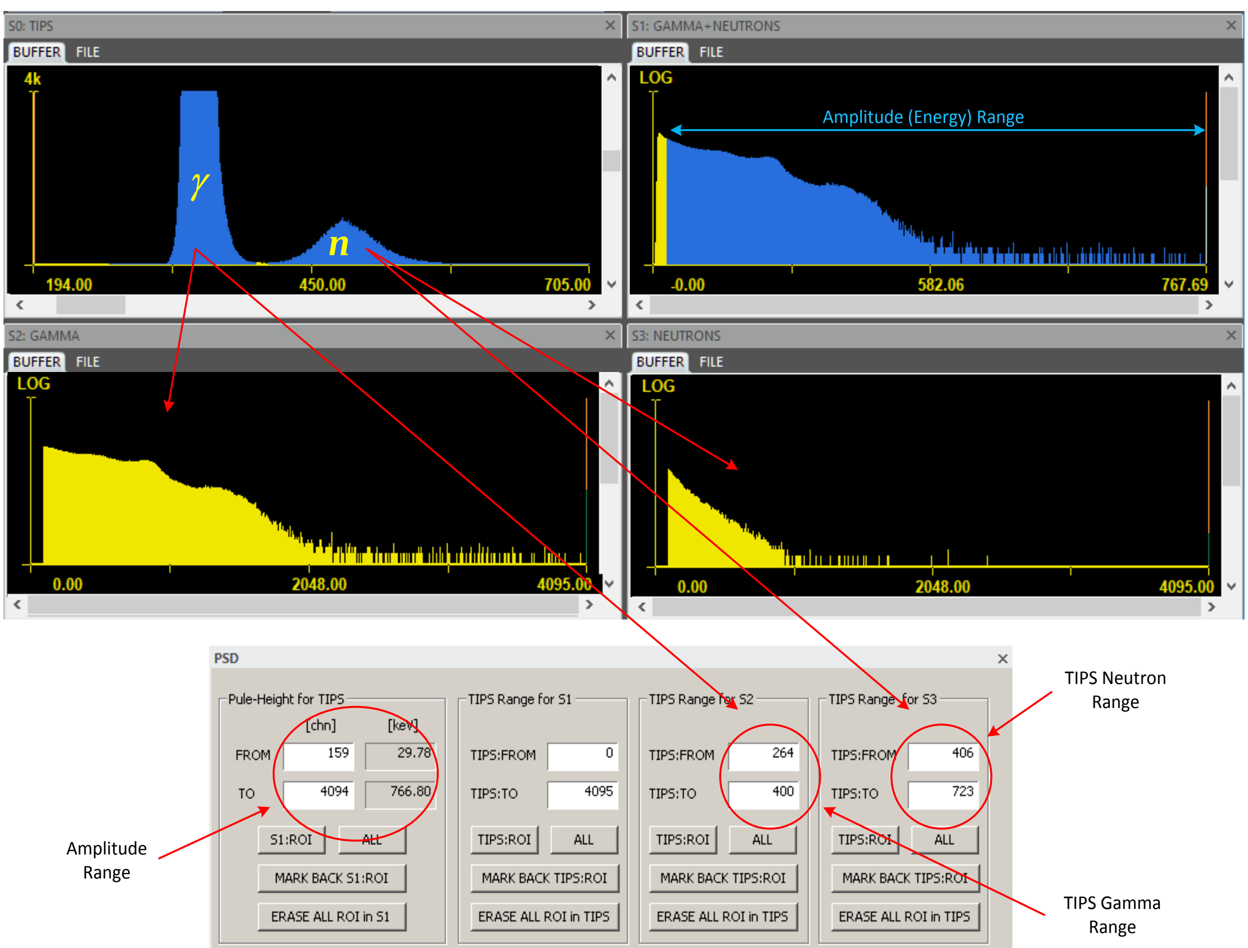


Figure 2.2.19. Relationship between PSD controls and the spectrum acquisition.

The groups "TIPS:ROI for S2" an "TIPS:ROI for S3" are used to enter a pulse-shape discrimination range of TIPS by selecting appropriate ROIs in the S0:TIPS spectrum window. For example, if a neutron-gamma TIPS spectrum the gamma peak can be marked by an ROI and entered in the "TIPS:ROI for S2" while the marked neutron peak can be entered in "TIPS:ROI for S3**".** Fig 2.2.19 and Fig 2.2.20 illustrate the setting of S2 and S3 in simultaneous pulse-height and pulse-shape discrimination

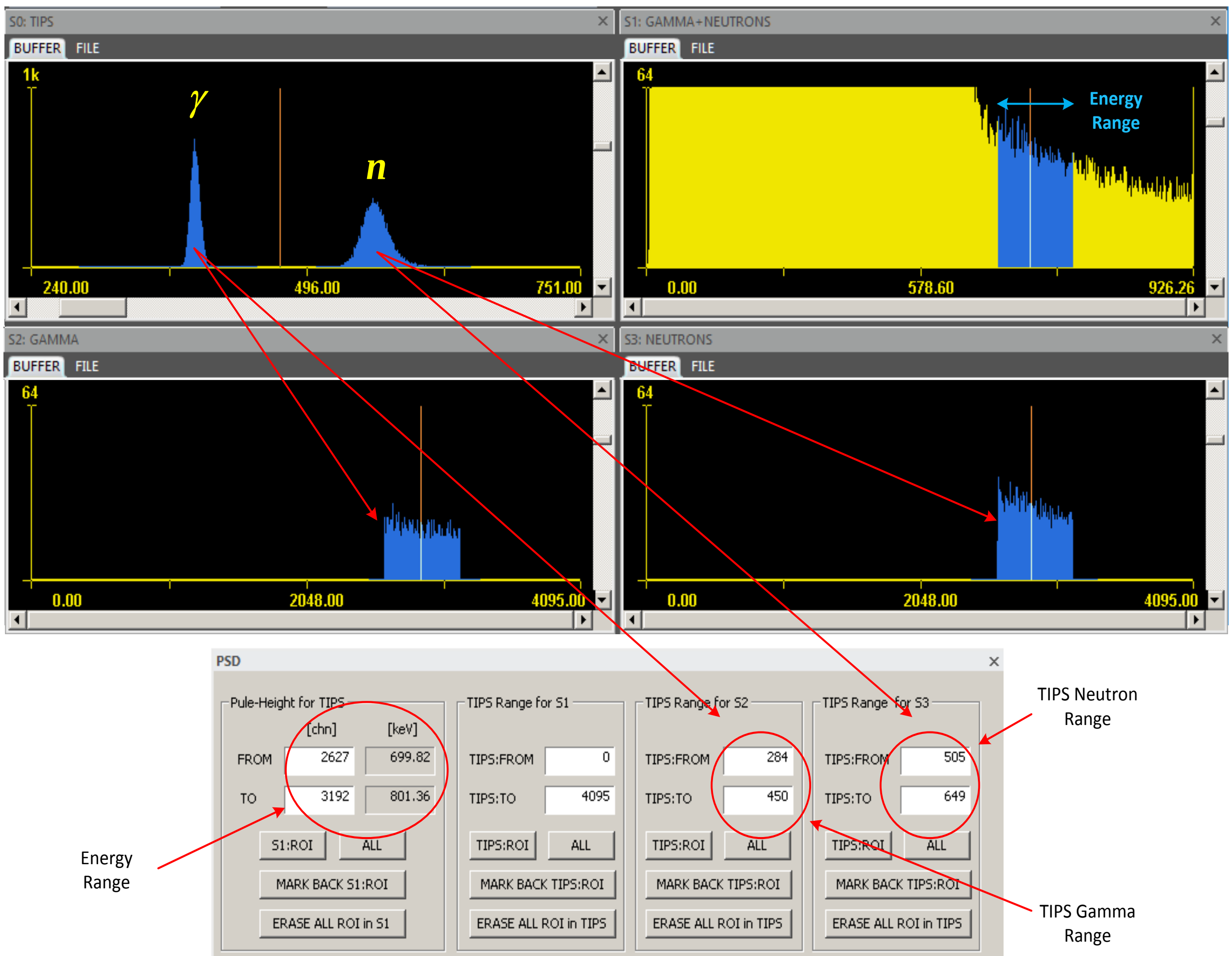


Figure 2.2.20. Simultaneous pulse-height and pulse-shape discrimination.

To set the ROIs in the PSD Window follow these steps assuming the signal processing has been set:

1. Connect the nanoPSD to the labZY-PSD application.
2. Press ALL in "TIPS:ROI for S1" resulting in ROI: from 0 to 4095.
3. Record a spectrum, S1 should display the full pulse-height spectrum

4. Select an ROI in S1 for desired pulse-heights (energy) to be used for the acquisition of the TIPS spectrum.

5. Erase spectrum and start new acquisition. TIPS spectrum should display a pulse-shape signature spectrum as shown in Fig. 2.2.19 or Fig. 2.2.20.

6. Mark ROIs around the TIPS peaks to be used for pulse-shape discrimination.

7. Place the cursor in each of these ROIs and press the ROI button of the corresponding "TIPS:ROI for S2" and "TIPS:ROI for S3" groups.

8. Erase spectra and start a new spectrum acquisition.

Acquisition Window

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

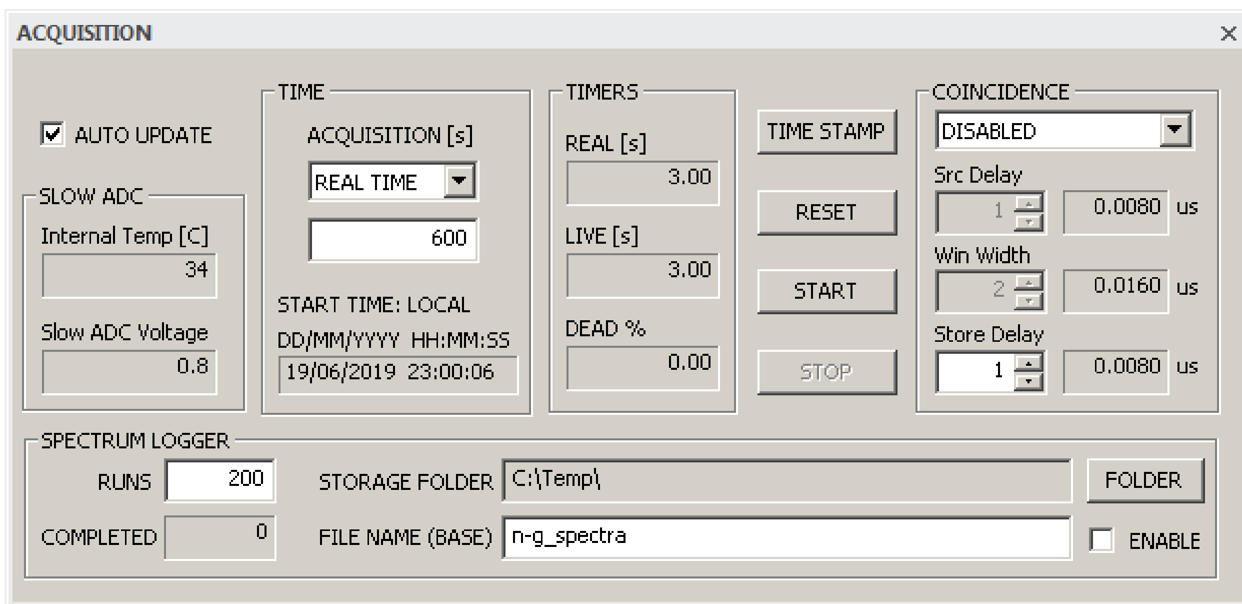


Figure 2.2.21. Acquisition Window.

The AUTO UPDATE checkbox controls the data exchange between labZY-PSD application 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.

The preset time of the spectrum acquisition is set by the controls in the group TIME. The preset time can be either LIVE TIME or REAL TIME. The preset time can be set in seconds. The TIMERS group reports the elapsed real and live time. The dead time is also reported.

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

The DATE/TIME button opens a dialog to select a time stamp for a given measurement.

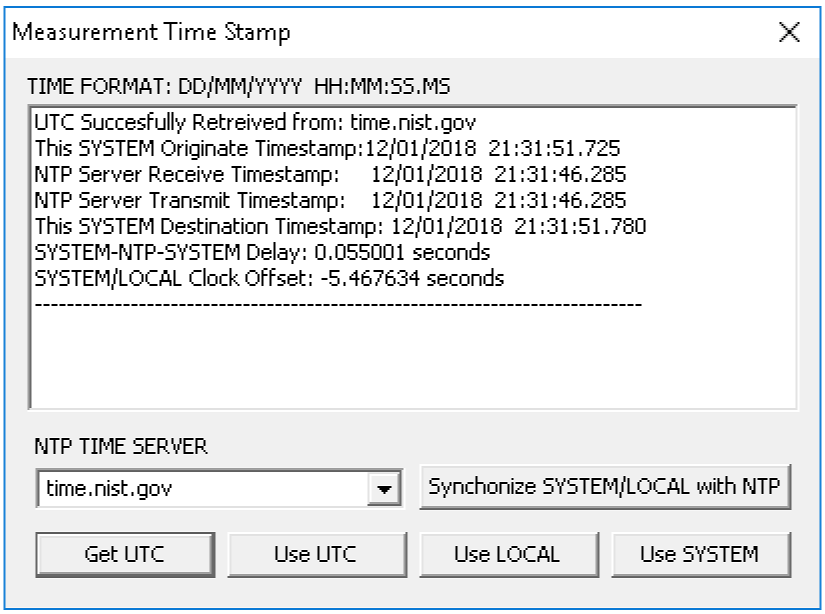


Figure 2.2.22. Time Stamp Dialog.

The time stamp may use UTC, LOCAL or SYSTEM time. the UTC can be obtained from internet time server with 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-PSD software will automatically open the dialog seen in Figure 2.2.22 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 the computer local host clock with the obtained NTP time; this function, however requires that the labZY-PSD is run as administrator.

The Acquisition Window also displays the volatile data - nanoPSD internal temperature and the voltage at Input D as measured by the slow ADC. The volatile data changes constantly. When stored in files, the volatile data represent the volatile state at the time the file is being saved.

The COINCIDENCE group is used to set-up the coincidence/anticoincidence function of the nanoPSD. The coincidence function uses Input R (settings from the SIGNALS Window) that drive an internal COINC_S signal. COINC_S can be a direct coincidence source directly or indirectly by edge-triggering a coincidence window pulse. In either case the resulting signal (direct or indirect) is COINC_W . The coincidence/anticoincidence is between the internal STORE signal derived from the timing peak detector signal, and the COINC_W signal.

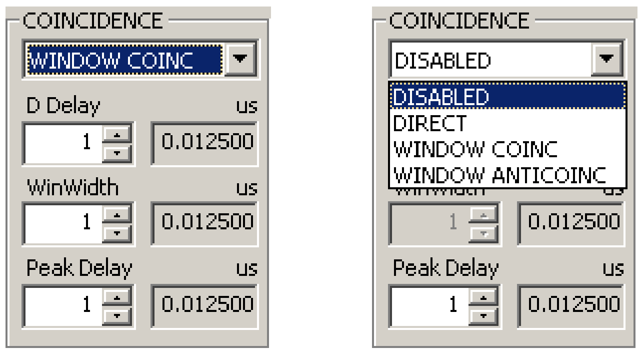


Figure 2.2.23. Coincidence Controls.

The coincidence function is selected from the drop-down list. When the DISABLED is selected, the coincidence/anticoincidence circuit is disabled.

When DIRECT is selected the COINC_W is directly connected to the Input R logic signal and is in coincidence when high and in anticoincidence when low. By selecting the polarity (inverted or not) of Input R the coincidence and anticoincidence functions can be reversed.

When one of the WINDOW coincidence functions is selected a window logic signal is generated by the low-to-high transition of COINC_S. The width of the window logic pulse is set in the WinWidth control. In this case COINC_W is the window logic signal.

The COINC_W signal can be delayed to align with the internal, peak-detector derived signal STORE. The delay is set by the D Delay control. The COINC_W can be selected to function as coincidence or anticoincidence signal.

The internal STORE signal can be delayed to accommodate coincidence or anticoincidence with external signals that may have long propagation delays or become active after the internal peak detection signal. The STORE signal delay is set by the Peak Delay control. Adjustments of the delays and the coincidence window width can be accomplished using the Trace Viewer. Double pressing the Input C trigger button will switch the Input C trace to COINC_S and the INHIBIT trace to COINC_W.

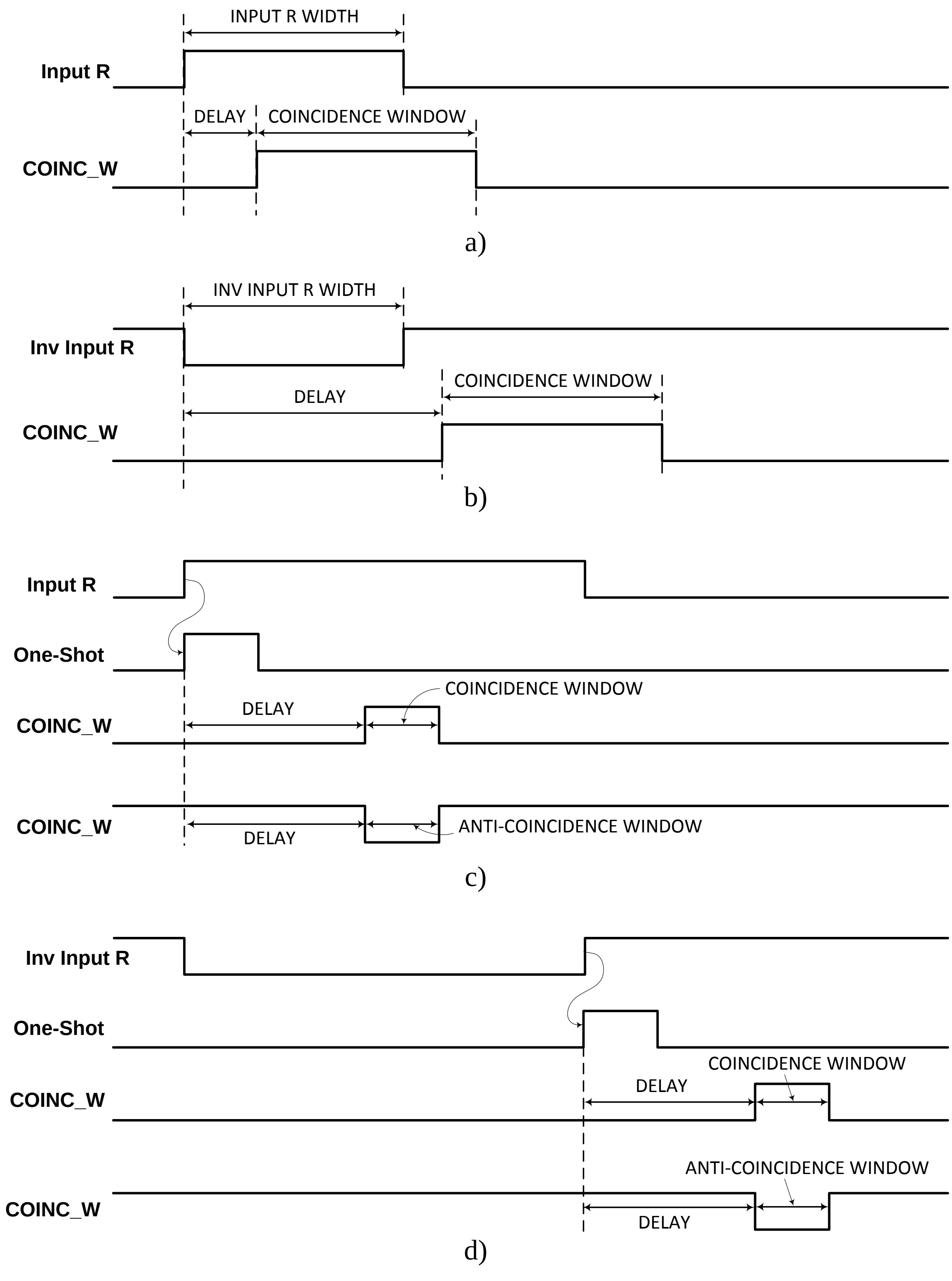


Figure 2.2.24. Timing diagrams of the built-in coincidence circuit: a) Input R (Coincidence HIGH) as DIRECT coincidence signal, active high or anti-coincidence signal, active low; b) Input R (Coincidence LOW) as DIRECT coincidence signal, active low or anti-coincidence signal, active high; c) positive edge and d) negative edge coincidence/anti-coincidence triggered signals.

The SPECTRUM LOGGER allows repeated spectrum acquisition and storage. The logger is implemented in the labZY-PSD software and requires active connection with a nanoPSD device during the entire time of measurement and logging the spectra.

The logger allows repeated storage of spectra acquired at identical settings for a preset number of RUNS. Each run of the logger represent a single spectrum acquisition for the preset LIVE or REAL time. At the end of the run the spectrum is stored, the spectrum memory is reset and a new spectrum acquisition is initiated. There is a gap between the runs. The minimum gap time is 1s or 2s when the REAL preset spectrum acquisition time is an odd number or even number of seconds respectively. The gap may be longer depending on the speed of the computer to write the acquired spectra.

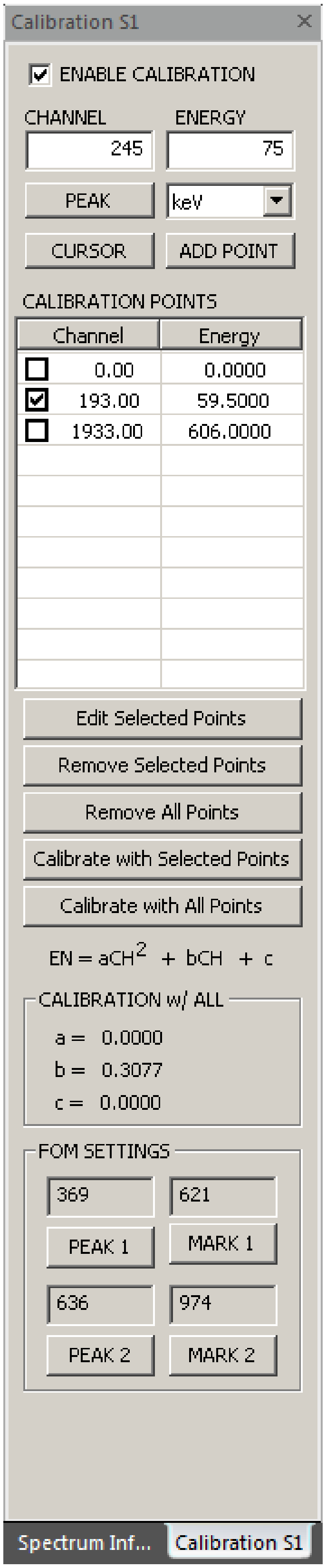
The spectra are stored in files with file names that are combination of the FILE NAME (BASE) and the number of the run (starting with 1) saved in the file as shown below - five runs with base file name *n-g_spectra*:

n-g_spectra_0001.lps
n-g_spectra_0002.lps
n-g_spectra_0003.lps
n-g_spectra_0004.lps
n-g_spectra_0005.lps

The storage folder is selected by pressing The FOLDER button. To start the logging the box ENABLE is checked followed by a press of the START button. To stop the logging before the preset numbers of spectrum records are reached the ENABLE box must be unchecked.

Each spectrum is time stamped. The time stamp of the first spectrum can be UTC synchronized or synchronized with the computer clock. a selection that can be made by pressing the TIME STAMP button before enabling the logger. The time stamps of all measurement following the first measurement are derived from the computer clock directly or by applying the initial UTC offset if the UTC time stamp is used for the first measurement. The cock time drift can be estimated by finding the UTC offsets at the beginning and the end of the measurement. Consequently the time stamps of the individual measurement can be corrected using the clock uncertainty and drift measurements.

The logging process will be terminated if the connection between the labZY-PSD and the nanoPSD fails due to power failure or communication errors or time out conditions.



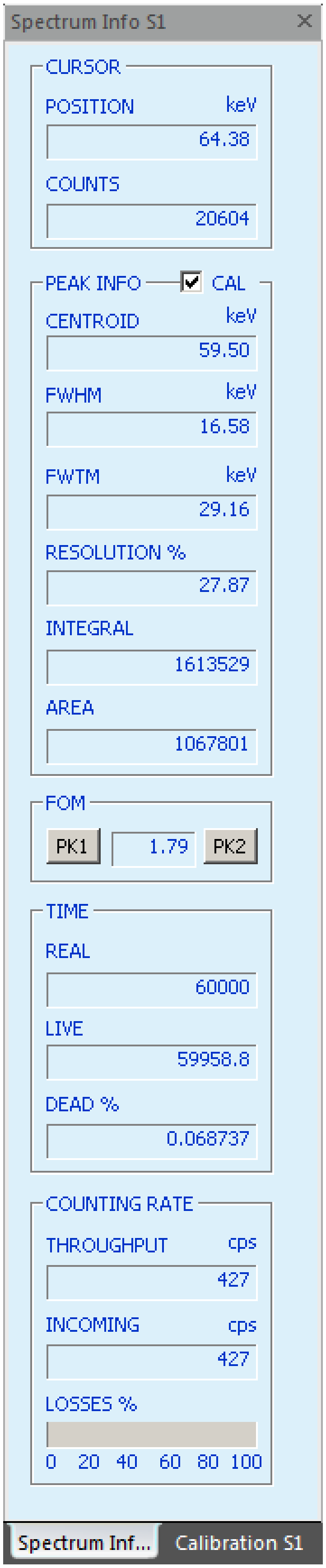
Calibration Window

The Calibration Window has the energy calibration settings. Each spectrum window (S0 to S3) has its own calibration settings independent from other windows. The window that a given Calibration applies to is indicated in the Calibration Window caption, e.g. **Calibration S1** for S1 Spectrum Window. Buffer and File tabs also have their own sets of calibration data.
labZY-PSD utilizes up to 10 points to calculate a second order calibration. To set the calibration coefficient, add up to 10 channel-energy points. The entry of the CHANNEL data can be manual, ROI PEAK centroid or CURSOR position. To enter a PEAK centroid position or CURSOR position, place the cursor in the CHANNEL entry and press the left mouse button to place the cursor. For PEAK centroid position, select an ROI, place the spectrum cursor within the ROI, and press the PEAK button. To enter the CURSOR position, move the spectrum cursor to the desired channel and press the CURSOR button. The ENERGY values must be entered manually. Press ADD POINT to transfer the CHANNEL/ENRGY values as a calibration point in the calibration points table.

After all points are entered the calibration coefficients can be calculated either using all points or a subset of calibration points selected by check marks. Calibration points can be removed or edited by first selecting the points (check mark) and then pressing the corresponding button.

The calibration units are selected from the drop-down choice list. Check the Enable Calibration check box to display the spectrum information in calibration units.

The FOM SETTINGS group allows a selection of two peaks whose centroids and FWHM are used to calculate FOM. Select a ROI around desired peaks in the TIPS spectrum (S0). Place the cursor in the first peak and press PEAK 1. Place the cursor within the ROI of the second peak and press PEAK 2. The ROIs of the FOM settings can be marked back in the TIPS spectrum by pressing MARK 1 and/or MARK 2 buttons.



Spectrum Info Window

The Spectrum Info Window displays read-only information about the spectra (S0 to S3) 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 FOM group displays the FOM of TIPS peaks as set in the Calibration window. PK1 and PK2 mirror the functions of the PEAK1 and PEAK2 buttons of the Calibration Windowand can be used to modify FOM Settings without switching to the Calibration Window.

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 indication of the dead time on a short time scale. At low counting rates, the reported losses may show large variations due to the 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.

Trace Viewer Window

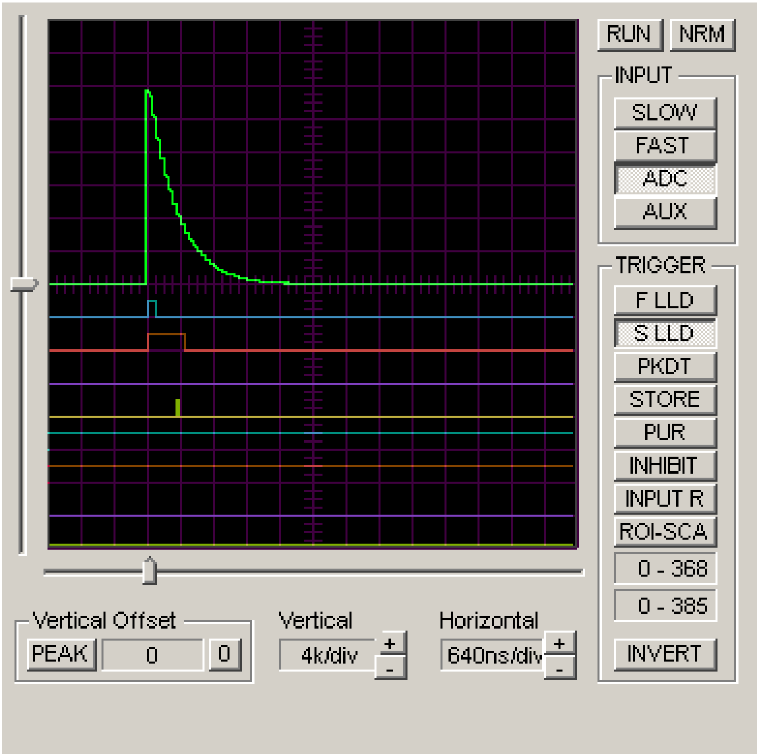


Figure 2.2.25. Normal size Trace Viewer Window.

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.

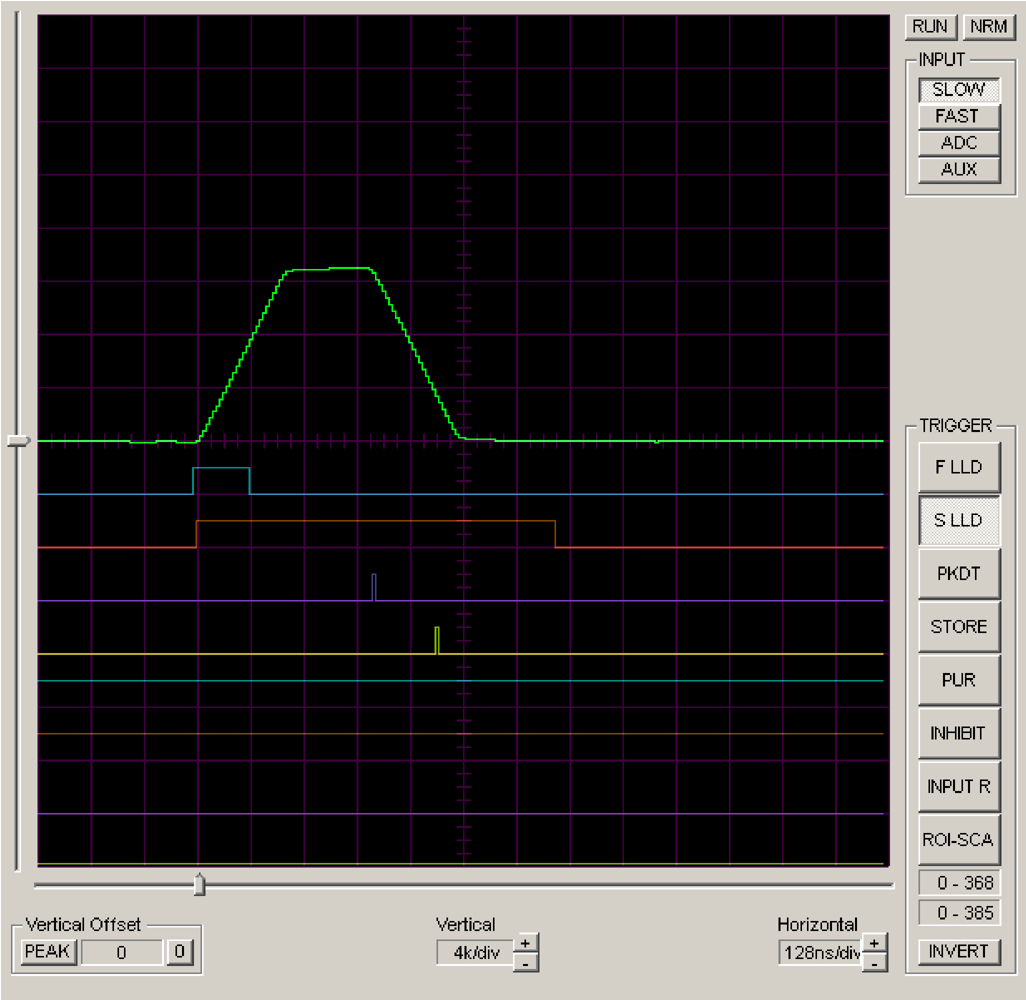


Figure 2.2.26. Large Size Trace Viewer Window

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.

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

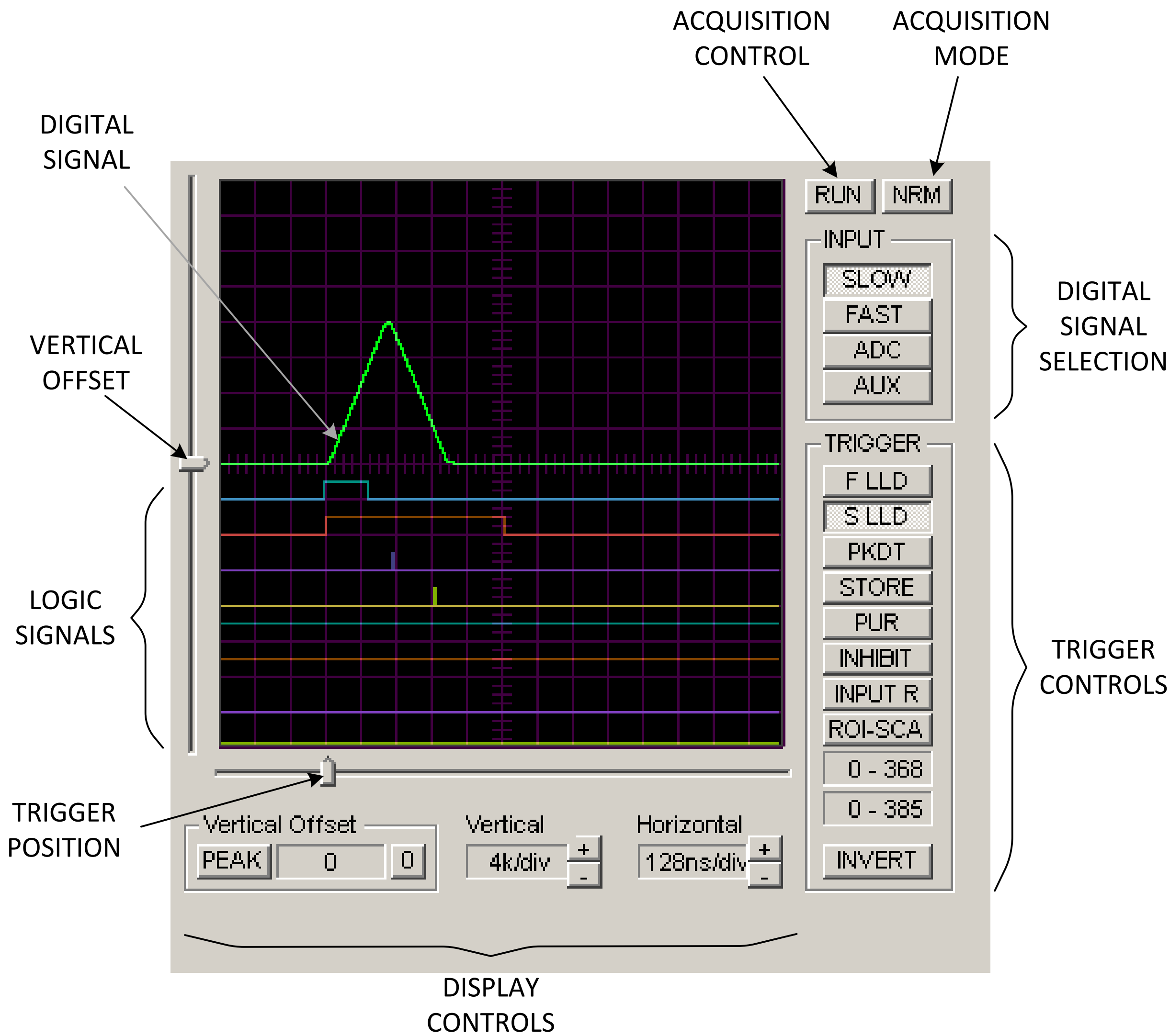


Figure 2.2.27. Controls and features of the Trace Viewer.

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 by using the Horizontal control by pressing + or – buttons. The vertical scale is chosen from preset values by pressing + 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 pressing consecutively the ACQUISITION MODE button.

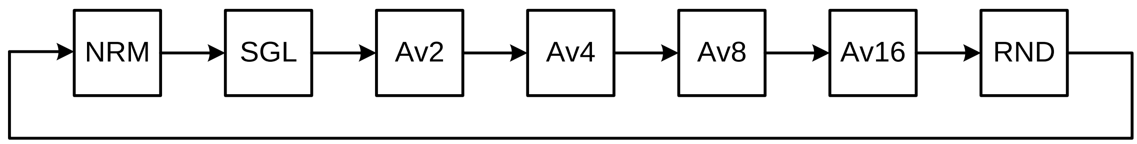


Figure 2.2.28. Acquisition Mode selection sequence using the ACQUISITION MODE button

The 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 accomplished, 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 nanoPSD. 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 forall 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 of the state of Input R button. The Input R button is a dual purpose button. When depressed and clicked, this button changes its own functionality and 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 R + INHIBIT and the second pair is Coinc S and Coinc W. This allows a total of ten logic signals to be used as triggers and their traces displayed.

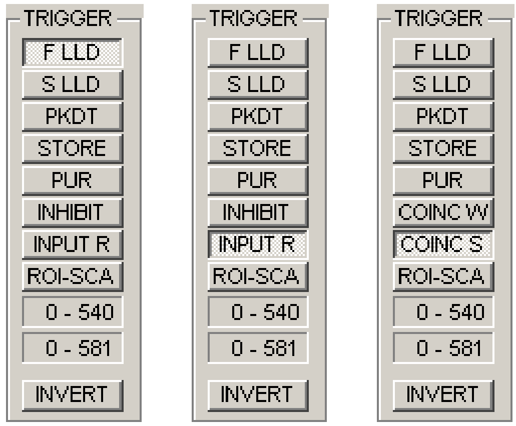


Figure 2.2.29. Input R and Inhibit trigger options.

The ROI trigger is a very special and useful option, allowing triggering by events with pulse heights or TIPS 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 in one of S0 to S3 spectra 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.

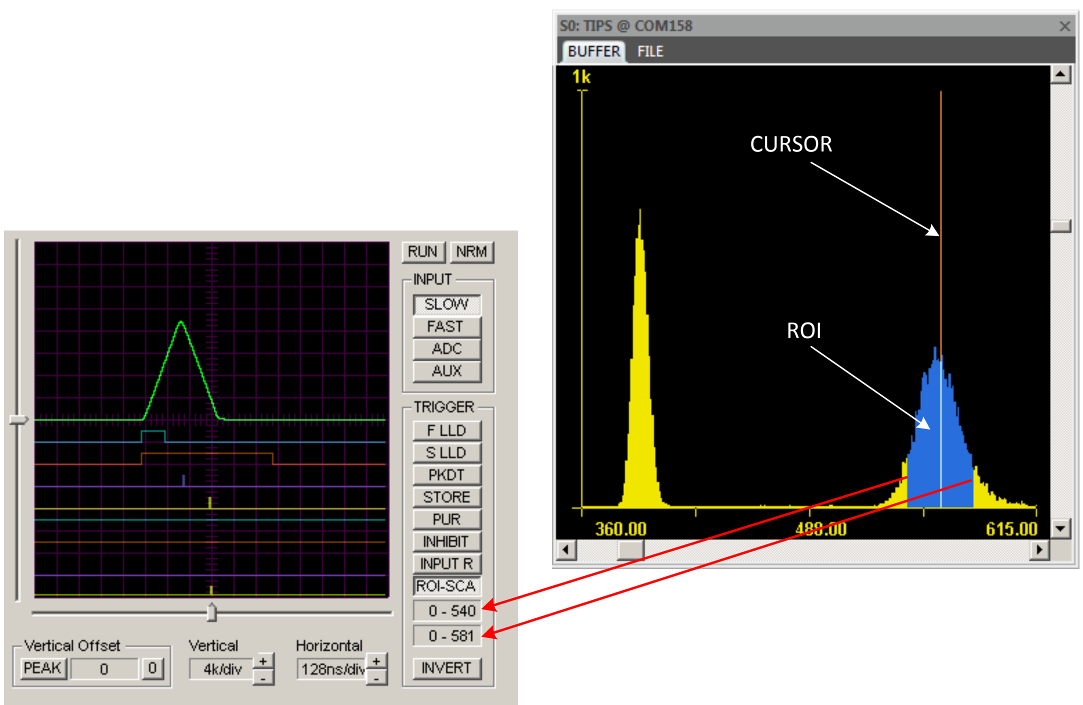


Figure 2.2.30. Setting the ROI trigger

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 fine adjustment of the LONG TC by observing the flat top of the digital signal at the highest possible vertical resolution.

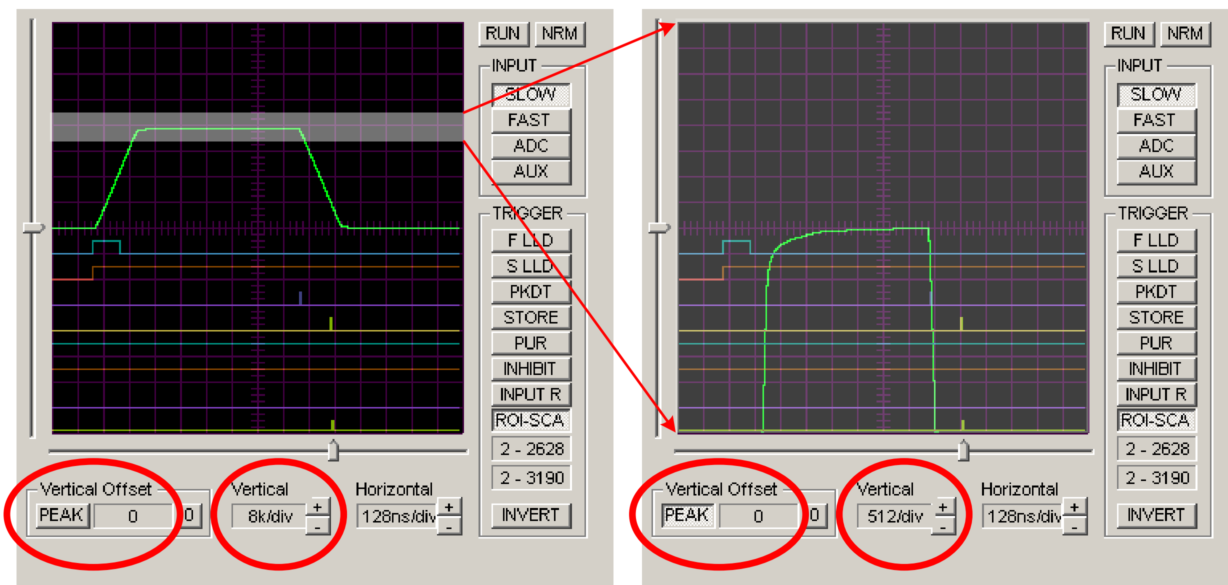


Figure 2.2.31. Peak referenced signal, The PEAK button is depressed. Using fine Vertical scale details of the peak portion of the shaped pulses can be observed.

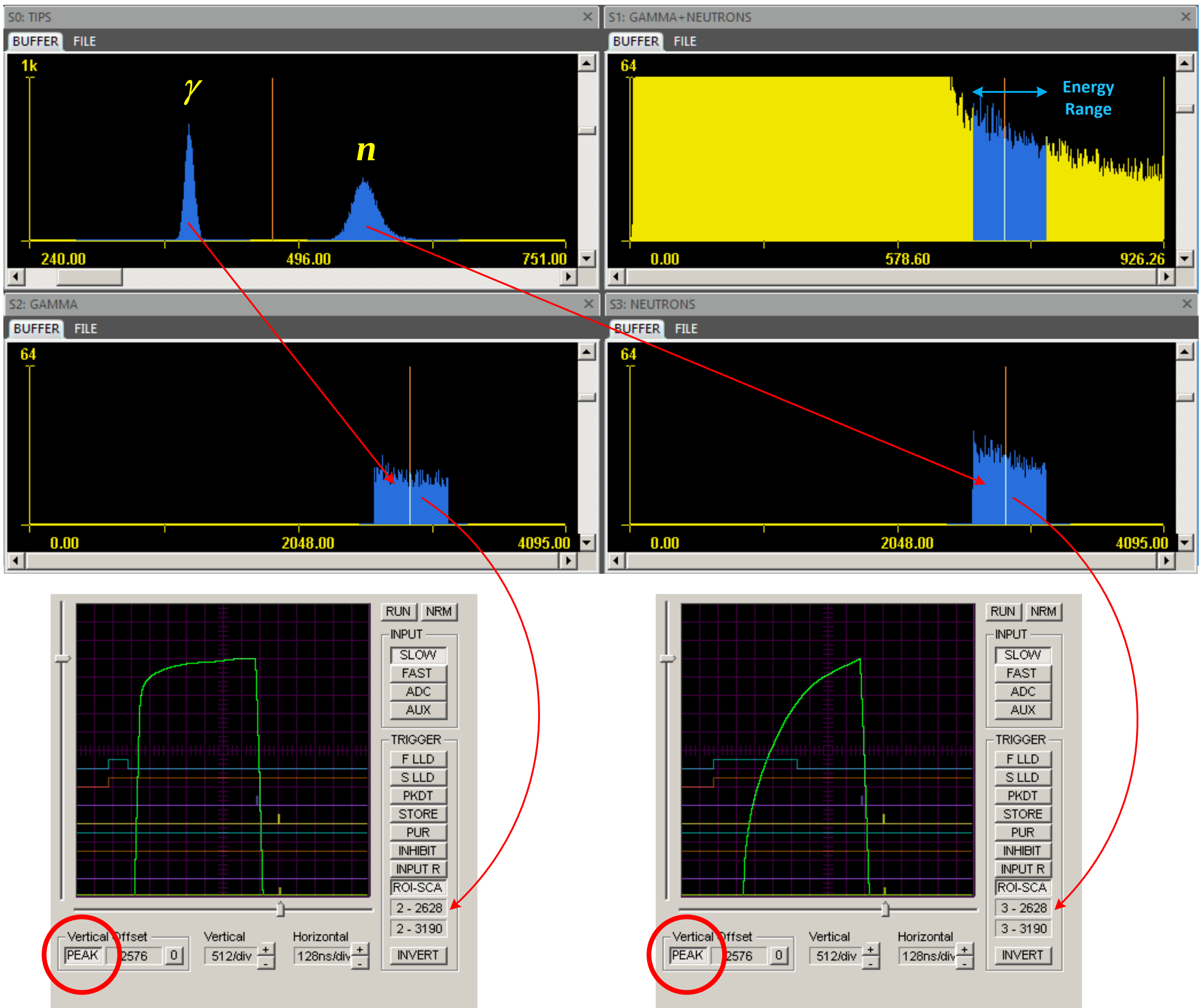


Figure 2.2.32. Peak portion of trapezoidal pulses with 200ns rise time and 800ns flat top. Trace a) is for gamma interaction in stilbene detector, trace b) represents neutron interaction.

Debug Window

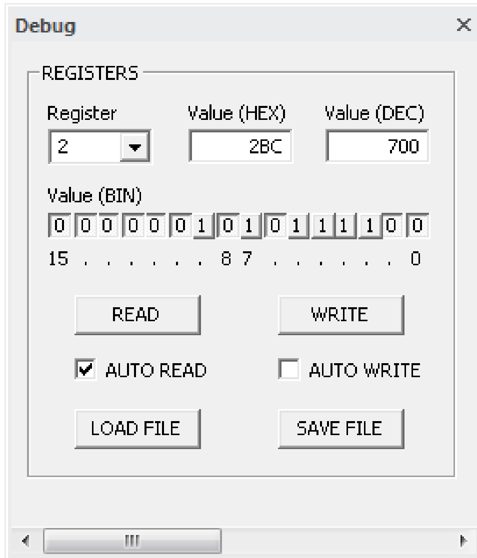


Figure 2.2.33. Debug Window.

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

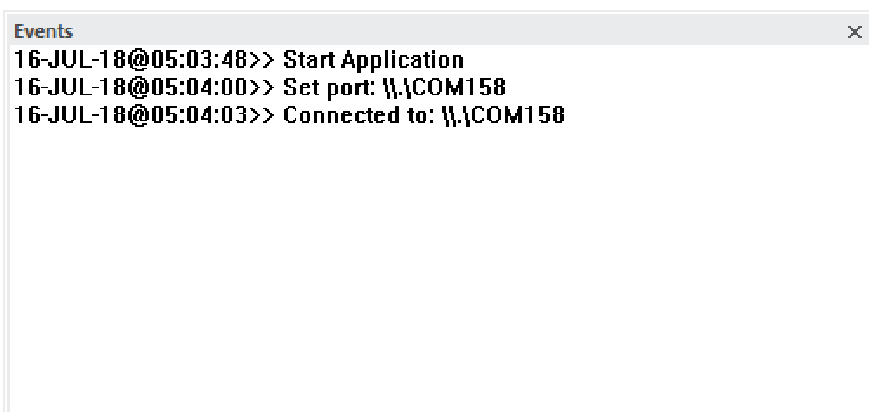


Figure 2.2.34. Events Window.

Various system level events are displayed in the Events Window.

Device Bars

Standard


Figure 2.3.1. Standard device bar.

Button function from left to right:

-  Information about labZY-PSD application.
-  Open file.
-  Save spectrum as...
-  Restore Layout.
-  Default Layout.

Hardware Control

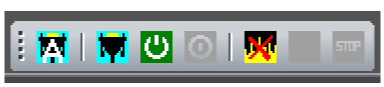


Figure 2.3.2. Hardware not connected.

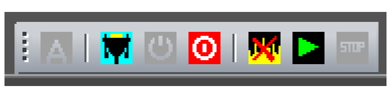
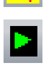


Figure 2.3.3. Hardware connected. Spectrum acquisition stopped.


Figure 2.3.4. 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

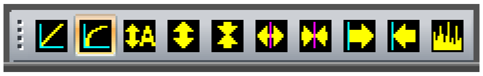


Figure 2.3.5. Viewer Control device bar.

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.

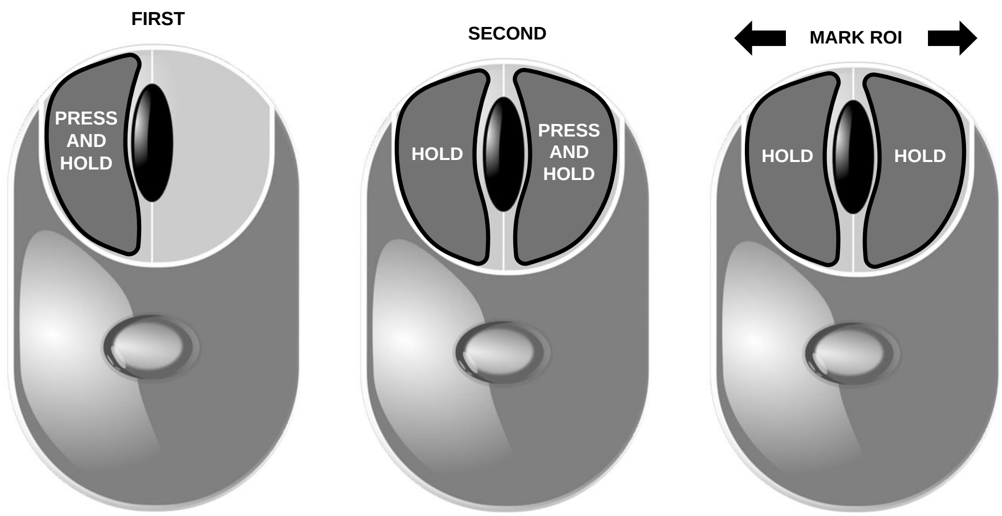


Figure 2.4.1. How to mark an ROI using the mouse.

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

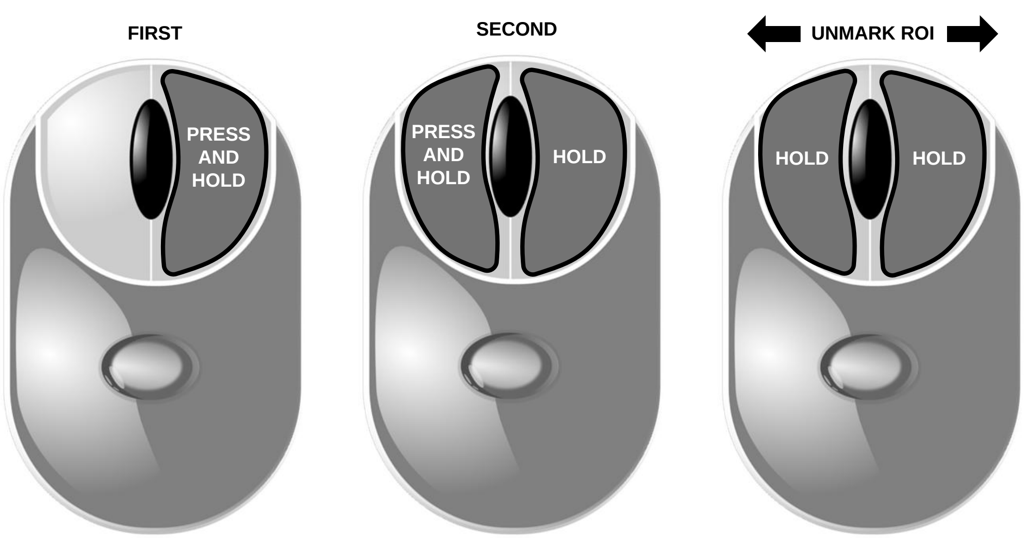


Figure 2.4.2. How to unmark an ROI using the mouse.

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.

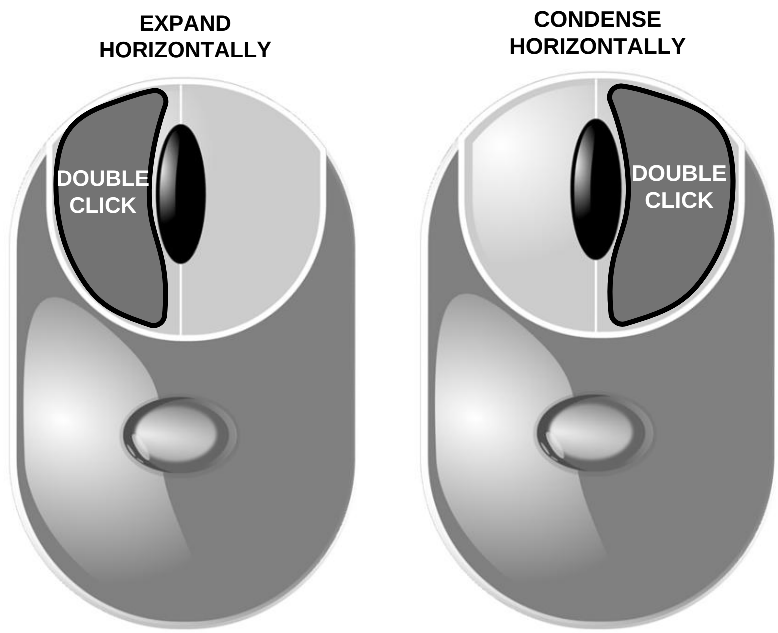


Figure 2.4.3. How to expand and condense the spectrum display horizontally.

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.

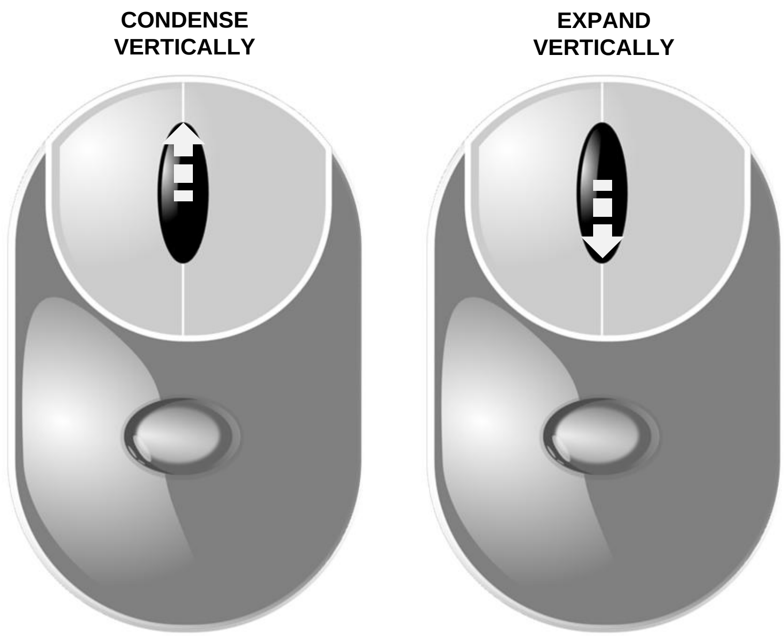


Figure 2.4.4. How to expand and condense vertically the spectrum display.

Appendix A: labZY-PSD File Format (.lps)

```
<?xml version="1.0"?>
<nanoPSD>
 <serialnumber>10012</serialnumber>
<spectrum0>
```

Hardware

```
  <tag>Stilbene; 50keV to 1.2MeV</tag>
  <caption>TIPS</caption>
  <hardsize>4096</hardsize>
  <softsize>4096</softsize>
```

Spectrum0 (S0) + tag caption and spectrum size information.

```
  <data>
0
82
44
.
.
.
346
+567
+1054
+1109
+985
+605
588
561
.
.
.
5
2
1
  </data>
```

S0 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.

```
</spectrum0>
<spectrum1>
  <tag>Stilbene; 50keV to 1.2MeV</tag>
  <caption>G+N</caption>
  <hardsize>4096</hardsize>
  <softsize>4096</softsize>
  <data>
0
1
2
.
.
127
438
783
.
.
```

Spectrum1 (S1)

```
.
.
25
9
  </data>
</spectrum1>
<spectrum2>
  <tag>Stilbene; 50keV to 1.2MeV</tag>
  <caption>GAMMA</caption>
  <hardsize>4096</hardsize>
  <softsize>4096</softsize>
  <data>
0
+55
+60
.
.
400
588
561
.
.
5
2
1
  </data>
</spectrum2>
```


Spectrum2 (S2)


```
<spectrum3>
  <tag>Stilbene; 50keV to 1.2MeV</tag>
  <caption>NEUTRONS</caption>
  <hardsize>4096</hardsize>
  <softsize>4096</softsize>
  <data>
0
1
2
.
.
127
438
783
.
.
0
0
  </data>
</spectrum3>
```


Spectrum3 (S3)

```
<time>
  <real> 2000.0000</real>
  <live> 1954.4138</live>
  <dead>    2.2793</dead>
  <date>14/07/2018  03:38:22</date></date>
</time>
```


Time and date information.


```
<calibration0>
  <enabled>NO</enabled>
  <units>0</units>
  <useall>NO</useall>
</calibration0>
<calibration1>
  <enabled>YES</enabled>
  <units>2</units>
  <channelA>    0.0000</channelA>
  <energyA>    0.0000</energyA>
  <useA>0</useA>
  <channelB> 1933.0000</channelB>
  <energyB>  606.0000</energyB>
  <useB>0</useB>
  <useall>YES</useall>
</calibration1>
<calibration2>
  <enabled>NO</enabled>
  <units>0</units>
  <useall>NO</useall>
</calibration2>
<calibration3>
  <enabled>NO</enabled>
  <units>0</units>
  <useall>NO</useall>
</calibration3>
```


Calibration data


```
<fom>
  <left1>369</left1>
  <right1>621</right1>
  <left2>636</left2>
  <right2>974</right2>
</fom>
```


FOM ROIs

```
<registers>
  <size>128</size>
  <data>
0
8000
160
20
8
.
.
.
.
0
0
0
  </data>
</registers>
<volatile>
  <firmware>50.20</firmware>
  <intemp>49</intemp>
  <slowadc> 0.74</slowadc>
</volatile>
</nanoPSD>
```


Hardware Register record Register 0 to Register 127.

Volatile data

Appendix B: Setting BDC

To set the BDC follow these steps:

1) Use BDC = 1 to setup a measurement, all other measurement parameters must be set before proceeding to step 2

2) Acquire S1 spectrum at 4096 channel soft size and adjust the gain so that there are well above the half of the full spectrum size (4096) (Fig B1).

3) Mark an ROI around the middle of the spectrum (channel 2048).

4) Place the cursor within the ROI and press ROI-SCA trigger button of the Trace Viewer.

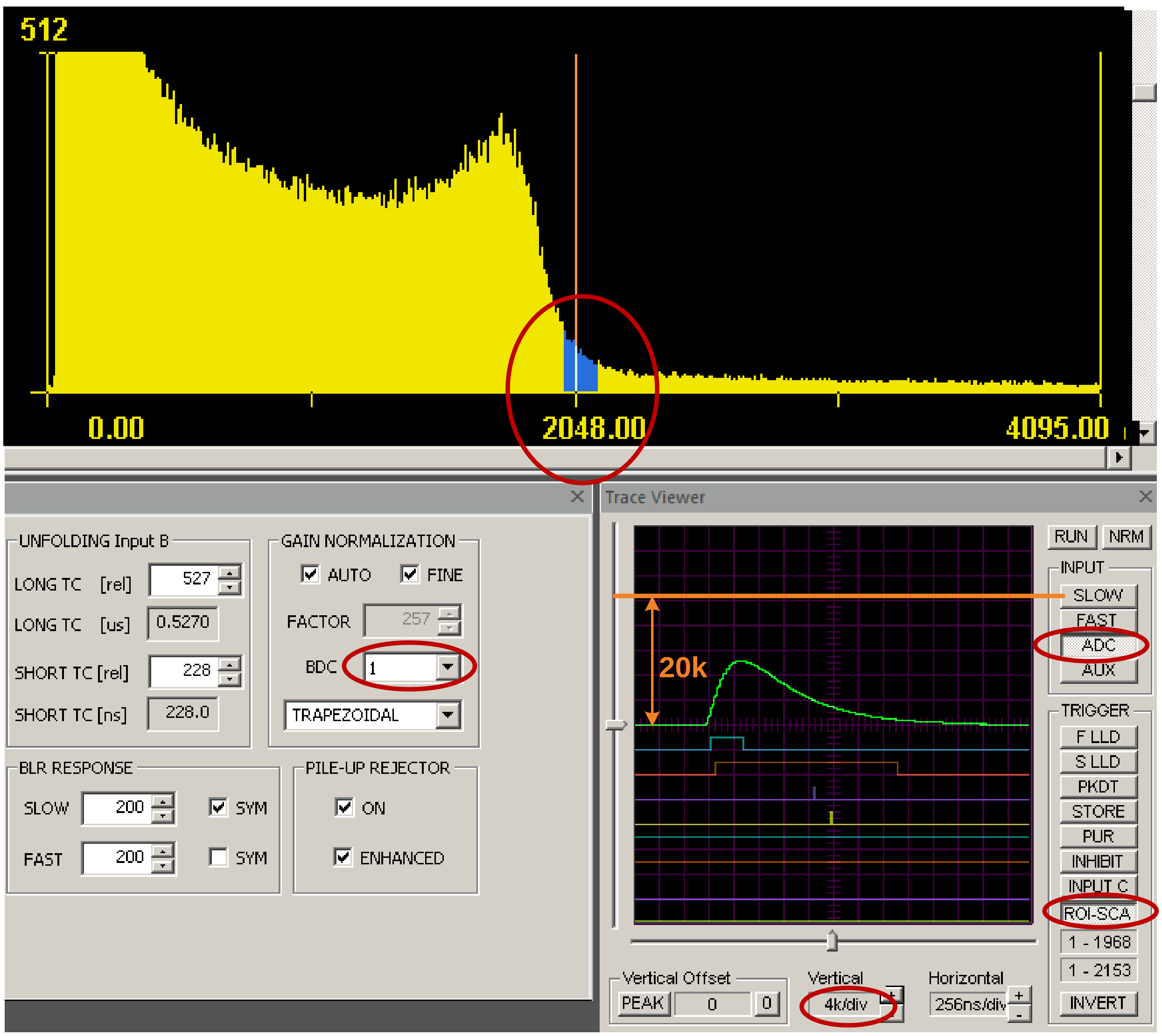


Figure B1. BDC not optimally adjusted

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, 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

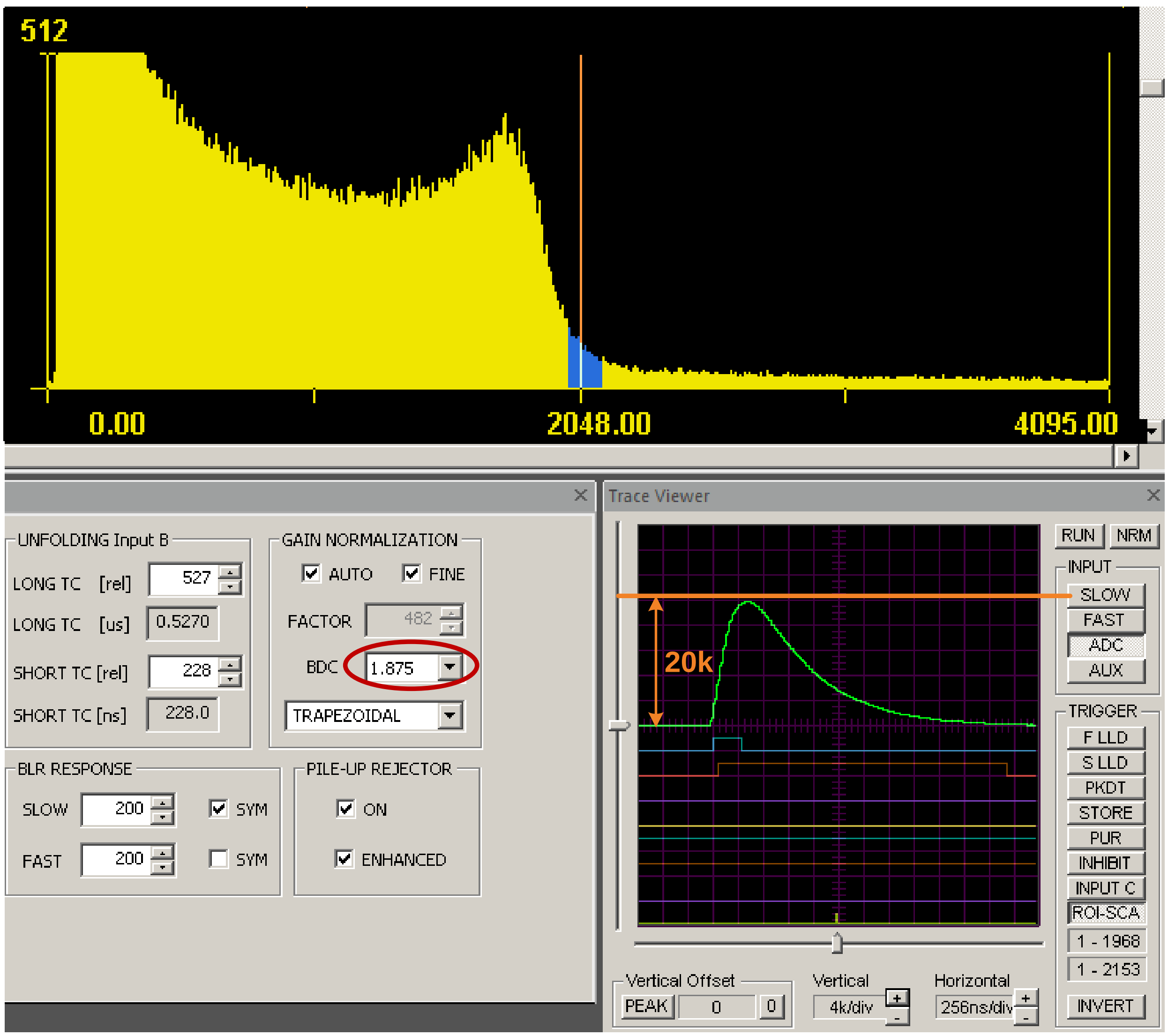


Figure B2. Optimally adjusted BDC.