TABLE OF CONTENTS

1. INSTALLATION
2. SYSTEM ARCHITECTURE
3. DEFAULT SCREEN
4. DATA ORGANIZATION: EXPERIMENTS & MEASUREMENTS
5. EXPERIMENT PROPERTIES
6. MEASUREMENTS
7. PRESETS
8. DETECTOR PULSE PLOT
9. SPECTRUM PLOT
10. SPECTRUM CALIBRATION
11. CALIBRATION STANDARDS
12. CONFIGURING SPECTRUM CHANNELS
13. HISTORY PLOT
14. HISTOGRAM PLOT
15. RISE TIME PLOT
16. RAW DATA PLOT
17. SUMMARY
18. MEASUREMENT COMPARISON
19. REGIONS OF INTEREST
20. WINDOWED ANALYSIS
1. INSTALLATION

If you are using a NEUTRON-LITE, a GAMMA-LITE or a UNIVERSAL MCA products connect the device to your PC via the supplied USB cable - Fig. 1. Do not use USB hubs - connect directly to your computer.

![Fig. 1. GAMMA-LITE system connected to PC laptop via USB 2.0 cable.](image)

Install the latest version of PicoSDK: 32-bit version if you are using 32-bit Windows or 64-bit version if you are using 64-bit Windows, then copy PulseCounter software folder from the flash drive to your PC and run PulseCounter.exe.

Unless you are using an UNIVERSAL MCA, the PulseCounter software supplied with the system you purchased is already configured and calibrated for the neutron or gamma detector in your system. So no additional setup is necessary.

The software supplied with the UNIVERSAL MCA product, however, will require configuration, tuning and calibration to properly work with a detector that you intend to use with your UNIVERSAL MCA system.

NEUTRON-PRO and GAMMA-PRO devices - Fig. 2, 3 - come equipped with touch-screen tablets that already have PulseCounter software installed and configured. No additional configuration or tuning (aside for occasional calibration) is necessary.
Fig. 2. NEUTRON-PRO system equipped with touch-screen tablet.

Fig. 3. GAMMA-PRO system equipped with touch-screen tablet.
2. SYSTEM ARCHITECTURE

Hardware & software architecture of Maximus Energy radiation detection systems is shown on Fig. 4.

![Diagram showing the architecture of Maximus Energy radiation detection systems](image)

PulseCounter software communicates with the DAQ via USB. Hence high-quality USB connectivity is hugely important. PulseCounter controls the Bias Supply via the DAQ to set the desired detector bias. When recording a measurement, PulseCounter is using the DAQ to acquire a continuous stream of data at a specified sample rate. PulseCounter performs digital signal processing in real time, extracts and counts detector pulses, builds and displays pulse-height (energy) spectrum, reports count rate and other data.
3. DEFAULT SCREEN

The DEFAULT screen of PulseCounter application is shown on Fig. 5. Throughout the program’s button colors are used as follows:

- **Yellow** buttons designate options that can be toggled on or off (active state is indicated by white text);
- **Green** buttons designate actions that result displaying of a new UI panel or dialog;
- **Blue** buttons correspond to actions;
- **Teal** buttons on the right allow navigating between the program screens;
- **Orange** buttons indicate file input / output;
- **Red** buttons indicate data creation or data acquisition.

![Fig. 5. PulseCounter DEFAULT screen.](image)

PulseCounter title bar displays the name of the computer the PulseCounter is running on and reports the program status (e.g. Running, Stopped, or Aborted). When running PulseCounter reports data acquisition performance as a percentage. Under normal conditions the performance figure must be close to 100% and should not decline. Declining performance figure indicates a configuration or a performance problem, which must be corrected in order for PulseCounter to function properly. When PulseCounter can’t achieve 100% performance it may drop samples, in which case it will report the percentage of dropped samples in red on the DEFAULT screen. Dropped samples are an indicator of a
serious problem that may invalidate the measurement results since portions of the detector signal were not processed (e.g. underreported counts).

All PulseCounter screens are organized in three sections:

- Left panel displays controls pertaining to the current experiment / measurement;
- Middle panel displays measurement data (such as detector pulse, spectrum, counts history, etc.)
- Right panel allows navigating between different screens and displays controls specific to the current screen and to the currently selected plot (e.g. when you click on a plot, controls specific to the selected plot will appear on the right panel).
4. DATA ORGANIZATION: EXPERIMENTS & MEASUREMENTS

PulseCounter organizes data in experiments. When PulseCounter is loaded it searches for the Experiments folder in the directory from which the PulseCounter.exe was launched, enumerates all available experiments, populates the EXPERIMENT list, and loads the last used experiment (if any). You can load a desired experiment by selecting an item from the EXPERIMENT list.

Each experiment can have one or more ‘BACKGROUND’, ‘EXPERIMENT’, or ‘CALIBRATION’ measurements. Typical experiment would have a number of ‘BACKGROUND’ and a number of ‘EXPERIMENT’ measurements, usually interleaved. All ‘EXPERIMENT’ and ‘BACKGROUND’ measurements are aggregated together into a ‘SUMMARY’ measurement used to calculate statistical significance (P-value) of the ‘EXPERIMENT’ measurements with respect to the ‘BACKGROUND’ measurements. ‘CALIBRATION’ measurements are used to check calibration and therefore are ignored in statistical analysis.

Each experiment is stored in its own subfolder in the Experiment directory with the general experiment information saved in .pulse file and individual measurements saved in .measurement files. Here is a sample directory structure for an experiment called TEST, which has 3 measurements: background, experiment, and calibration:

    Experiments
      → TEST
        → TEST.pulse
        → 1E.measurement
        → 2B.measurement
        → 3C.measurement

Each measurement is numbered sequentially (e.g. 1, 2, 3, etc) and the measurement number is followed by the measurement type code: ‘E’ for experiment, ‘B’ for background, or ‘C’ for calibration.

So, a typical workflow amounts to creation of a new experiment followed by recording of one or more measurements. One can deleteIndividual measurements or entire experiments as well as add new measurements to an existing experiment.

Each experiment can keep track of counts in different units, such as counts per second (CPS), counts per minute (CPM), counts per hour (CPH), or custom units.

Each measurement is characterized by mean count rate & standard deviation, total counts, pulse-height / energy spectrum, count rate history, count rate histogram, pulse rise time histogram, mean pulse rise time & standard deviation. Optionally, a measurement can contain a pulse train, and raw detector signal, which is stored in a separate .raw file.

For any measurement spectrum, count history, count histogram and rise time histogram can be exported into a CSV file.
5. EXPERIMENT PROPERTIES

When PulseCounter is launched for the first time the EXPERIMENT list is empty and one has to click the NEW button to display a CREATE NEW EXPERIMENT dialog and specify the experiment properties in order to create a new experiment. The experiment properties are organized in pages as follows:

- **NAME**, Fig. 6 - specify a non-empty EXPERIMENT NAME; the name must contain only alpha-numeric characters (e.g. symbols such as ‘:’ or ‘\’ or not allowed). The CREATE button will be automatically enabled once you type a non-empty EXPERIMENT NAME.

![Create New Experiment Dialog](image)

Fig. 6. CREATE NEW EXPERIMENT dialog, NAME page.
• **UNITS**, Fig. 7 - choose **COUNT UNITS** such as counts per second (CPS), counts per minute (CPM), counts per hour (CPH), etc. or setup your own count units by typing a unit name in the **COUNT UNITS** field and type a number in the **SECONDS PER UNIT** field. E.g. to specify counts per millisecond type ‘milliseconds’ in the **COUNT UNITS** and type 0.001 in the **SECONDS PER UNIT**. The **LABEL** field updates automatically informing you of the abbreviated ‘Counts Per xxx’ (CPx) label that will be used by the PulseCounter to label the counts.

![Fig. 7. CREATE NEW EXPERIMENT dialog, UNITS page.](image)

**Fig. 7. CREATE NEW EXPERIMENT dialog, UNITS page.**
- **LOGGING**, Fig. 8 - indicate if you want to log **PULSE TRAIN** or **RAW SIGNAL**. Logging pulse train creates a list of all recognized detector pulses (time stamp, rise time, and magnitude) whereas logging raw signal dumps the entire unprocessed detector signal into a .raw file. Logging pulse train is useful for ‘lossless’ spectrum rebuilding while logging raw signal is useful for signal auditing and signal reanalysis (e.g. when you record a measurement and log the raw signal you can go back to the measurement, modify the preset and click the **REANALYZE** button in order to extract counts and rebuild spectrum from the raw signal using a different set of signal processing parameters).

Fig. 8. CREATE NEW EXPERIMENT dialog, LOGGING page.
• **COMPRESSION**, fig. 9 - applies only when the logging **RAW SIGNAL** option is selected. Because logging raw signal generates large amounts of data, the file has to be compressed in order to save disk space. Selecting **FAST** option compromises compression speed for compression efficiency (i.e. generates slightly larger files). Fast compression should be used when the system fails to perform full compression in real-time. **LOSSY** option should be checked when capturing very large data sets: lossy compression substitutes samples between recognized pulses with zeros and thus significantly reduces the compressed file size (although at a loss of some data).

**Fig. 9. CREATE NEW EXPERIMENT dialog, LOGGING page.**
- **SOUND**, Fig. 10 - selecting sound **ON PULSE** causes a click every time a count is recorded. Selecting sound **ON FINISH** causes a ‘ta-da’ sound played upon the completion of a measurement.

Fig. 10. CREATE NEW EXPERIMENT dialog, SOUND page.
- **PERFORMANCE**, Fig. 11 - you can specify a number of the INTERNAL CHANNELS used to quantize detector pulse amplitude for spectrum construction (applies only when the PULSE TRAIN logging option is not selected, otherwise the pulse train is used for spectrum rebuilding).

**EXPECTED COUNT RATE** is used to allocate memory for the pulse train acquisition ahead of time for improved performance (applies only when the PULSE TRAIN option is selected).

When checked, the AUTO-SUMMARY option updates the ‘SUMMARY’ measurement automatically each time a new measurement is captured and when an experiment is loaded (the ‘SUMMARY’ measurement is always computed on the fly as it is not stored on disk). When working with very large data sets updating the ‘SUMMARY’ measurement may take a long time, in which case one can uncheck the AUTO-SUMMARY option and update the summary manually when needed by clicking the UPDATE button on the SUMMARY page.

![CREATE NEW EXPERIMENT dialog, PERFORMANCE page.](image)
- **HARDWARE**, Fig. 12 - you can specify **WARM UP TIME**, which is a time delay in seconds PulseCounter waits after applying bias to detector prior to data acquisition. Note that PulseCounter turns on the bias voltage when one starts a new measurement by clicking the **START** button. The bias voltage stays on until one closes PulseCounter (this measure has been implemented to minimize bias drift).

Some Maximus Energy radiation detectors can acquire data on multiple channels simultaneously, in this event the **CHANNELS** box number can be set to 2 (1 channel is used by the vast majority of devices).

![Fig. 12. CREATE NEW EXPERIMENT dialog, HARDWARE page.](image)
- **REMOTE**, Fig. 13 - allows configuring your device as a component in the Automated Nuclear Lab (ANL) system. The **SERVER** field specifies a name or an IP address of the ANL master computer that controls the devices and aggregates the data. The **GROUP** field identifies the group this device belongs to (e.g. Gamma, Neutron, etc.). The **DEVICE** field specifies this device’s name. The **TIMEOUT** field specifies network communication timeout in seconds;

![CREATE NEW EXPERIMENT dialog, REMOTE page.](image-url)
• **STATISTICS**, Fig. 14 - allows specifying **SIGNIFICANCE** percentage value (default 5%) used for **P-value** calculation. P-value is used to determine if the ‘EXPERIMENT’ counts are significantly different from the ‘BACKGROUND’ counts.

Fig. 14. CREATE NEW EXPERIMENT dialog, STATISTICS page.
Click the **CREATE** button to create a new experiment. PulseCounter will create a new experiment file & folder, update the **EXPERIMENT** list and display a slightly different version of the **DEFAULT** screen - Fig. 15.

![Fig. 15. DEFAULT screen of a new experiment.](image)

Clicking the **PROPERTIES** button allows viewing / modifying properties of the current experiment. Some properties such as **NAME**, **UNITS**, **LOGGING**, and **CHANNELS** cannot be modified and are fixed for all measurements in the experiment. All other properties can be modified in between the measurements.

Clicking the **DELETE** button located above the **MEASUREMENT** label will remove the current experiment from disk and from the **EXPERIMENT** list.
6. MEASUREMENTS

A newly created experiment has no measurements, so a new empty measurement is created automatically and the **START** button (which starts a new measurement acquisition) is enabled right away.

If the experiment is not new and contains previously recorded measurements the measurement list is enabled and you can pick a measurement you wish to view, including the ‘SUMMARY’ measurement (which merges together the counts, histories and spectra of all ‘EXPERIMENT’ and ‘BACKGROUND’ measurements and loads the aggregated background as a [comparison](#)). To create a new measurement click the **NEW** button under the **MEASUREMENT** label.

Before you start a new measurement select a measurement type (‘BACKGROUND’, ‘EXPERIMENT’, or ‘CALIBRATION’) from the measurement type list under the **MEASUREMENT** label. The measurement ID displayed in the now disabled measurement list will automatically reflect the measurement sequence number and type.

Each measurement can have textual **NOTES** associated with it. To enter new measurement notes simply type in the **NOTES** box. To modify notes of a completed measurement edit the text in the **NOTES** box and click the the **UPDATE** button (which will appear under the **NOTES** box as soon as you modify the notes) to save the changes. For convenience the new measurement notes persist when a new measurement is created.

The **DURATION** box allows specifying the measurement duration in **COUNT UNITS** (e.g. seconds, minutes, etc.) The **# MEASUREMENTS** box indicates how many measurements are going to be captured back to back without pausing. When the **INTERLEAVE** option is selected each new measurement will automatically toggle between ‘BACKGROUND’ and ‘EXPERIMENT’.

To start a new measurement acquisition click the **START** button or click the **CANCEL** button if you wish to discard the newly created measurement without recording any data.

When a new measurement is being acquired PulseCounter displays current count rate under the **CPx** label, mean count rate under the **MEAN** label, standard deviation under the **DEVIAITION** label, and total counts under the **TOTAL** label. PulseCounter also reports mean pulse **Rise Time** ± standard deviation and pulse **Decay** constant (in **AREA** mode only).

The measurement acquisition will complete when the **ELAPSED TIME** reaches the specified **DURATION**. If the **# MEASUREMENTS** field is greater than 1 the next measurement will begin immediately. To abort the new measurement acquisition click the **STOP** button.

To delete a completed or aborted measurement click the **DELETE** button.
7. PRESETS

Each measurement is stored together with a preset used to acquire the data. **It is hugely important** to set up (or load) the correct preset designed for the detector and data acquisition hardware being used. To set up or inspect the preset click the **PRESET** button. PulseCounter will display the preset parameters in the right panel - Fig. 16.

![Fig. 16. Preset panel.](image)

If the measurement is new all the preset parameters can be modified. If the measurement has already been acquired one can only view the preset parameters used to capture the data. However, if the **RAW SIGNAL** logging option was selected one can modify the preset of an already acquired measurement and click the **REANALYZE** button to have PulseCounter load the recorded raw signal from the `.raw` file and rebuild the measurement from scratch by reanalyzing the recorded raw signal using the modified preset.

The preset parameters are as follows:

- **DETECTOR BIAS** - almost all radiation detectors require bias voltage to function. A typical Maximus Energy system comes with a programmable high voltage power supply. Specify a value between 0 and 3,000 to set a positive detector bias voltage. Note, that specifying incorrect bias voltage may damage your detector. Also note that when using the **UNIVERSAL MCA** system bias generation is optional and will have no effect if only the signal input is used. E.g. you can use an externally (positively or negatively) biased detector with the **UNIVERSAL MCA**. In this case set the **DETECTOR BIAS** value to zero to turn off the built-in bias supply as a precaution against electric shock via unterminated SHV connector and to reduce electronic noise.
• **SIGNAL RANGE** - specifies the maximum expected signal amplitude generated by the detector. As a rule, one has to choose the smallest range value for maximum pulse-height resolution. E.g. if your Maximus Energy system is fitted with an 8-bit DAQ you have only 128 quantization levels for pulse height sampling. Therefore selecting excessive range will reduce spectrum energy resolution. In the same time, selecting too low of a range will limit the maximum pulse energy as pulses with larger amplitude will clip. Thus, there is always a trade-off between maximum pulse energy and pulse-height resolution. Typical ranges are 50 mV for neutron detectors and 0.5-2V for gamma detectors. 16-bit PRO-series Maximus Energy systems support signal ranges as low as 10 mV and 20 mV. These ranges are not available on 8-bit LITE-series devices and selecting them will result in failure to start measurement. Minimum range for an 8-bit system is 50 mV.

• **POS / NEG** option specifies positive or negative expected detector pulse polarity. Typically positively biased detectors generate negative pulses and negatively biased detectors generate positive pulses. However, preamps may produce pulse polarity different from the detector pulse polarity.

• **SAMPLE RATE** - allows specifying data acquisition sample rate in Hertz. Different systems support different sample rates: e.g. 8-bit LITE-series devices are generally limited to 1 MHz, whereas 16-bit PRO-series devices can go up to 20 MHz. Keep in mind that high sample rates will extract significant toll on CPU because all signal processing is host-based. If your system fails to perform, reduce the sample rate. Also, it makes no sense to use a high sample rate with a slow detector. E.g. most gas-filled neutron counter tubes have a signal rise time on the order of 10-20 microseconds. Thus, sampling rate between 500 kHz and 1 MHz is more than enough to adequately capture the signal and accurately extract the pulse amplitude. On the other hand, NaI(Tl) scintillator-based gamma detectors typically produce pulses with rise time on the order of 1 microsecond. Therefore sampling rates between 1 and 5 MHz are best for the scintillators. So, I recommend 1 MHz for gas-filled neutron counters and 5 MHz for scintillators (1 MHz for an 8-bit system). Lastly, some Maximus Energy systems adjust the specified sample rate up or down due to ADC clock quantization. So do not be alarmed if the specified sample rate changed slightly when you inspect the preset after recording a measurement.

• **TRIGGER** - PulseCounter uses trigger level expressed in millivolts to detect pulses. A negative trigger value should be used for negative pulse polarity and a positive trigger value for positive pulse polarity. Note that in **PEAK mode** the trigger specifies signal amplitude, whereas in **AREA mode** the trigger specifies differential amplitude (e.g. signal change between samples). Too low trigger value may result in high count rates due to triggering on noise. If this happens increase the absolute value of the trigger. Too high trigger value will result in exclusion of low-energy pulses. So there is always a compromise between noise and minimum pulse energy. Maximus Energy devices that are sold together with detectors are shipped with pre-configured presets that typically do not need modification. However, adapting a system to a different detector will require some trial and error in determining the optimal trigger value.
• **WINDOW** - detector pulse window in microseconds, used for the pulse plot and for pulse energy extraction. The ideal window size should match the detector pulse width (i.e. match the time it takes for a detector signal to return to zero).

• **BASELINE** - length of time in microseconds used for baseline sampling. Although baseline should always be zero, noisy systems or detectors overwhelmed with counts (e.g. when pulses pile up and ride on top of each other) produce baselines different from zero. So, when PulseCounter detects a pulse it samples the baseline prior to the pulse edge in order to subtract it from the pulse height for accurate pulse energy recovery. Generally baseline time should be short (e.g. 1-10 microseconds) to prevent bias drift caused by earlier pulses from introducing errors in the pulse energy determination.

• **RISE TIME** - specify maximum pulse rise time in microseconds. Accurate pulse energy determination critically depends on this parameter. Ideally, the RISE TIME value should match maximum detector pulse rise time. Actual detector pulse rise time can be slightly less than this value due to noise and aliasing. When unsure about the detector pulse rise time, enter some large value (e.g. 10-50 microseconds), which should be less than the window size. Record a test measurement, goto RISE TIME plot and examine the rise time diagram. There should be a single peak on the rise time diagram characteristic of the pulse rise time (multiple peaks indicate noise, detector malfunction, or sampling problems). Examine the rise time diagram and edit the preset by entering the maximum value from the diagram as RISE TIME. Do not enter values that are much larger than maximum pulse rise time: too large of a rise time will reduce PulseCounter’s ability to resolve closely spaced pulses.

• **PEAK / AREA** - determines pulse energy reconstruction algorithm. E.g. in AREA mode the pulse energy is determined by integrating the pulse area (the pulse area integration time is specified by the WIDTH parameter). In PEAK mode the detector signal is differentiated first. Then the trigger criterion is applied to the differentiated signal and the pulse energy is determined by integrating the differentiated signal (the integration time is determined by the RISE TIME). Generally the PEAK mode is superior to the AREA mode since it allows resolving closely spaced pulses because RISE TIME << WIDTH. Therefore, the PEAK mode will produce accurate energy spectrum even at an extremely high count rate where pulses ride on top of each other. However, the PEAK mode will not produce good energy resolution when used on an 8-bit LITE-series system due to 128 quantization levels available. Thus, one has to use the AREA mode with an 8-bit LITE-series system to obtain a good energy-resolved spectrum although at the expense of a reduced count rate (the spectrum will appear distorted when pulses start riding on top of each).

• **WIDTH** - pulse area integration time in microseconds, applies only to the AREA mode.

• **SCALE** - numerical scaling factor that relates pulse amplitude to pulse area, applies only to AREA mode. Set this parameter to zero when you want PulseCounter to determine the value automatically by integrating pulse area and dividing it by pulse amplitude. Note that changing the WIDTH will require recalculation of the SCALE. Changing the scale will result in shifting of
the spectrum peaks left or right depending on whether the SCALE value is decreased or increased.

- DECAY - numerical factor characterising exponential decay of detector pulses, applies only to the PEAK mode. PulseCounter uses the DECAY value to compensate for the exponential signal decay when integrating differentiated pulse samples. The decay value must be \( \leq 1 \). Improper decay value will reduce pulse energy resolution. Note that PulseCounter automatically calculates and displays the decay value in AREA mode but not in PEAK mode.

When one modifies the preset the APPLY button appears. Click the APPLY button to save the preset or click CANCEL to discard the changes.

While preset must be set up prior to new measurement acquisition, the preset can be modified during the measurement acquisition as well, except for DETECTOR BIAS, SIGNAL RANGE, and SAMPLE RATE values, which can be set only prior to measurement acquisition. Modifying the preset during the measurement acquisition is useful for tuning purposes (e.g. TRIGGER adjustment). Note that the SPECTRUM plot will be reset every time one clicks the APPLY button during the measurement acquisition.

The DEFAULT option indicates that the current preset will be used to initialize a new measurement when one is created (each experiment has its own ‘DEFAULT’ presets).

Click the LOAD button to load an existing preset from the list of the experiment’s presets - Fig. 17.
The **PRESET LIST** will contain all available experiment presets. Each experiment has a ‘DEFAULT’ preset and can contain additional user-defined presets. Select a preset from the **PRESET LIST** and click the **LOAD** button to load the preset and return to the Preset panel. Or click the **IMPORT** button to import a preset from a .preset file.

Click the **SAVE AS** button to save the current preset to the list of the experiment’s presets - Fig. 18.

![Graph showing data](image)

**Fig. 18.** Preset save-as panel.

Type a new preset name in the **PRESET NAME** box or select a preset from the **PRESET LIST** if you wish to overwrite an existing preset and click the **SAVE** button to save the preset. Or click the **EXPORT** button to export the preset to a .preset file.

If a measurement has already been acquired and the **RAW SIGNAL** logging option was not selected you can only view preset parameters when you click the **PRESET** button. However, if the **RAW SIGNAL** logging option was selected you can modify the preset values and click the **REANALYZE** button to have PulseCounter use the raw signal to refresh the measurement by recounting pulses and rebuilding spectrum.
8. DETECTOR PLOT

DETECTOR pulse plot is shown on Fig. 19.

![Detector Plot](image)

The red horizontal cursor line indicates the TRIGGER level. The red vertical cursor line indicates pulse start time (pulse edge). Time from the beginning of the plot to the beginning of the pulse corresponds to the BASELINE. Pulse plot width corresponds to the WINDOW. Vertical plot range corresponds to the SIGNAL RANGE. The pulse plot title indicates whether the current pulse is accepted or rejected, displays the pulse’s rise time, spectrum channel number or energy, and pulse start time.

Click the REJECTED button to toggle between accepted and rejected pulses. The accepted pulses are deemed valid and are included in spectrum calculation. The rejected pulses are deemed invalid because they are either clipped (i.e. the pulse height is over-range), their channel / energy lies outside the specified channel / energy limits, or the pulse rise time is outside of the allowed range.

If the PULSE TRAIN logging option was selected when the experiment was created one can navigate the recognized detector pulses after the measurement is completed by clicking NEXT or PREVIOUS buttons to go to the next or previous detected pulses. If the RAW SIGNAL logging option was also selected the detector plot will display the pulse shape by loading data from the .raw file.

Click the EXPORT PNG button to save the plot image as a PNG file.

Click the EXPORT CSV button to export the plot data as a comma-separated values text file (e.g. for subsequent import in a spreadsheet).
9. SPECTRUM PLOT

SPECTRUM plot is shown on Fig. 20.

![SPECTRUM Plot](image)

**Fig. 20. SPECTRUM plot.**

Click anywhere on SPECTRUM plot to display a red vertical cursor line. The cursor will snap to the nearest spectrum peak and the plot will display a Gaussian envelope of the peak. When the cursor is visible the label under the SPECTRUM plot will display the selected channel number (or channel energy when the spectrum is calibrated), number of counts in the channel, and (when applicable) the selected peak’s full width at half maximum (FWHM) value. Pressing left / right arrow keys moves the cursor left / right one channel.

When the **ZOOM** option is highlighted, selecting an area on the SPECTRUM plot will zoom to the selected area, otherwise a selection will remain on the SPECTRUM plot. One can also press and hold the shift-button on keyboard and drag mouse cursor across the SPECTRUM plot to select channels regardless of the state of the **ZOOM / SELECT** option. During a measurement acquisition this channel selection will limit pulse display to pulses with energies that fall in the specified channel range. Click the **UNSELECT** button to remove the selection.

Click the **LOGARITHMIC** button to switch between linear and logarithmic plot scales.

Click the **LINE PLOT** button to switch between bar (default) and line display modes.

The **MOVING AVERAGE** box allows specifying how many samples should be averaged together to smooth out a noisy spectrum.
10. SPECTRUM CALIBRATION

Spectrum CALIBRATION panel is shown on Fig. 21.

To calibrate the initially uncalibrated spectrum click on a peak (the cursor will automatically recognize the peak, draw a Gaussian envelope and snap to the peak’s center) and select corresponding calibration energy from the list of STANDARDS. The spectrum is now calibrated and you can save the calibration by clicking the SAVE button.

You can add as many calibration points as you want. The added calibration points appear in the CALIBRATION list. If you click on an item in the CALIBRATION list, the panel will display the pulse magnitude (<1) and the corresponding channel in case you want to edit the calibration values manually. Click the UPDATE button to save the manual changes or click the DELETE button to delete the selected calibration point.

You can adjust calibration by clicking on a red calibration diamond on the SPECTRUM plot and moving the diamond to a new location. Also, you can click anywhere on the SPECTRUM plot to position the cursor (use left and right arrow keys to manually move the cursor if it fails to snap to a desired peak), right-click and select a desired calibration energy from the context menu.

You can disable calibration without deleting it by selecting the IGNORE option. Once the IGNORE option is activated the SPECTRUM plot will switch to the uncalibrated view (e.g. displaying channel numbers rather than energies along the horizontal axis). You can still calibrate the spectrum even though the calibration is turned off.
Click the **RESET** button to erase all calibration data. The changes won’t take effect until you save the spectrum by clicking the **SAVE** button.

Calibration is specific to each preset. To exchange calibration data between the presets click the **EXPORT** button to export the calibration into a `.calibration` file, load a different preset and click the **IMPORT** button to import the calibration from a `.calibration` file, then save the preset.
11. CALIBRATION STANDARDS

Click the EDIT button to edit the list of the calibration standards - Fig. 22.

![Calibration Standards dialog]

Click on an item in the list if you wish to update to modify the standard NAME or ENERGY. Click the UPDATE button to update the item after the modification. If you type a standard name that is not yet in the list the ADD button will become enabled and clicking it will add the new standard to the list.

Click the DELETE button to remove a selected standard from the list.

Click the IMPORT / EXPORT button to import / export calibration standards from / to a .standards file.
12. CONFIGURING SPECTRUM CHANNELS

One can configure spectrum channels by clicking the **CHANNELS** button - Fig. 23.

![Fig. 23. Spectrum CHANNELS page.](image)

Select the desired number of channels from the **SPECTRUM CHANNELS list**.

Specify the energy of the last channel by entering a value in the **MAX ENERGY** field (the keV/CHANNEL value will be automatically calculated). Alternatively, modify the keV/CHANNEL value to specify the single-channel energy resolution in kiloelectronvolts (the **MAX ENERGY** value will be automatically calculated).

Select the **RISETIME FILTER** option if you want to limit spectrum to pulses with rise time that falls into a specified range given by the **MIN** and **MAX** values (see the **RISE TIME plot**).

Select the **CHANNEL FILTER** and specify the **MIN CHANNEL** and **MAX CHANNEL** values if you want the count rate, standard deviation and total counts to be limited to the specified channel range (e.g. pulses that fall outside the selected channel range will not be counted).

If you are modifying the spectrum channel settings for a measurement that has already been acquired, click the **REBUILD** button to rebuild the spectrum. The spectrum will be recalculated using the **INTERNAL CHANNELS** or using the pulse train if the **PULSE TRAIN** logging option was selected.
13. HISTORY PLOT

Count rate HISTORY plot is shown on Fig. 24. The HISTORY plot supports only zooming in response to selection. Count rate history is plotted in **COUNT UNITS**.

Fig. 24. HISTORY plot.
14. HISTOGRAM PLOT

Count rate HISTOGRAM plot is shown on Fig. 25. The HISTOGRAM plot does not support selection or zooming. Count rate histogram is plotted in **COUNT UNITS**. Note that under most circumstances the count rate histogram should approximate a Gaussian distribution.

![HISTOGRAM plot](image)

Fig. 25. HISTOGRAM plot.
15. RISE TIME PLOT

Histogram of detector pulse rise times is shown on Fig. 26. The RISE TIME plot supports both selection and zooming. When the RISE TIME plot receives a selection the **RISETIME FILTER** (spectrum CHANNELS properties) gets enabled and receives **MIN** and **MAX** values corresponding to the RISE TIME plot selection. Thus, selecting a range of values on the RISE TIME plot will modify spectrum.

Fig. 26. RISE TIME plot.
16. RAW DATA PLOT

RAW DATA plot is shown on Fig. 27.

Fig. 27. RAW DATA plot.

Raw data is divided into frames corresponding to a single COUNT UNIT (e.g. if the COUNT UNIT is a ‘SECOND’ then each frame is 1 second long). To navigate between frames use NEXT and PREVIOUS buttons. Zoom in by making a selection on the plot.
17. SUMMARY

Measurement summary is shown on Fig. 28.

![SUMMARY screen](image)

Fig. 28. SUMMARY screen.

The table at the top gives a summary of all ‘EXPERIMENT’ vs all ‘BACKGROUND’ measurements, including total duration, mean count rate, standard deviation, and total counts. In other words, the data reflects the ‘SUMMARY’ measurement.

The last two columns give P-value and establish statistical significance (e.g. report if the P-value is smaller than the predetermined SIGNIFICANCE level). ‘EXPERIMENT’ and ‘BACKGROUND’ count rate histories are used for P-value calculation.

The table in the middle summarizes all measurements by listing duration, mean count rate, standard deviation, and total counts.

The Experiment Summary plot displays a bar chart of all measurement counts: the ‘BACKGROUND’ measurements are colored blue and the ‘EXPERIMENT’ measurements are colored red.

If you have turned off the AUTO-SUMMARY the summary view may be out of date. Click the UPDATE button to initiate a manual refresh.
18. MEASUREMENT COMPARISON

One can compare individual measurements as shown on Fig. 29.

![COMPARE screen.](Image)

<table>
<thead>
<tr>
<th>EXPERIMENT</th>
<th>MEAN</th>
<th>DEVIATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>4E</td>
<td>3,010.50</td>
<td>± 53.51</td>
</tr>
<tr>
<td>TOTAL</td>
<td>180,630</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>EXPERIMENT</th>
<th>MEAN</th>
<th>DEVIATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1B</td>
<td>3,026.37</td>
<td>± 59.07</td>
</tr>
<tr>
<td>TOTAL</td>
<td>181,582</td>
<td></td>
</tr>
</tbody>
</table>

The COMPARE screen reports the P-value and statistical significance of the comparison: count rate histories of the compared measurements are used for the P-value calculation.

Click the **LOAD COMP** button to browse for and load a measurement for comparison. You can select a measurement from a different experiment if you wish: PulseCounter allows comparing measurements across experiments and displays the experiment name, the measurement ID and the data acquisition channel of the measurements being compared. The comparison plots are overlaid on top of the original plots and are colored pink.

Click the **COMP** button to show / hide the comparison plots display.

Enable the **SCALE COMP** option to force the height of the comparison spectrum to match the height of the source spectrum.

Select the **A&B** option to display the source and the comparison spectra overlaid. Select the **A-B** option to display the difference between the source and the comparison spectrum. Select the **B-A** option to display the difference between the comparison and the source spectrum.
19. REGIONS OF INTEREST

PulseCounter supports regions of interest. Click the ROI button to bring up the ROI page - Fig. 30.

To define an ROI select a desired range of spectrum channels and click the ADD button to add the new region to the ROI list. Specify the ROI name using the NAME box. You can edit the ROI channel and range manually by using the MIN CHANNEL and MAX CHANNEL fields.

To delete an ROI click the DELETE button.

You can import or export ROI definitions by clicking the IMPORT or EXPORT buttons.

Click the OK button to save the ROI definition. An ROI list will appear under the ROI button with ‘ALL CHANNELS’ item selected by default. Select an ROI from the list to see mean count rate and total counts specific to this ROI (see the DEFAULT screen). Also, the SPECTRUM plot will display channel selection corresponding to the selected ROI.

Fig. 30. ROI page.
20. WINDOWED ANALYSIS

The windows analysis feature - Fig. 31 - is not yet implemented.
21. TROUBLESHOOTING

If PulseCounter reports ‘Failed starting data acquisition’ error when you click the START button to acquire a new measurement or if the acquisition does not start and no error id displayed, try the following steps (in this order):

1) Exit PulseCounter, restart it and try again.

2) Make sure that your device is connected to the host PC via a USB cable.

3) Make sure that PicoSDK is installed. Uninstall the old SDK. Download and install the latest SDK: 32-bit version if you are using 32-bit Windows or 64-bit version if you are using 64-bit Windows.

4) Make sure that the specified SIGNAL RANGE and SAMPLE RATE are supported by your DAQ. If unsure about the supported signal range and sample rate use 50 mV range when counting neutrons and 500 mV when counting gammas and set the sample rate to 1,000,000 Hz.

5) Exit PulseCounter. Delete PulseCounter.config file, restart PulseCounter and try again.

6) If steps 1-5 do not help email to founder@maximus.energy for support.

If PulseCounter is running but you won’t achieve the performance figure (Fig. 32) between 96 and 100%, or if the performance figure declines with time, try the following (in this order):

1) Make sure that your device is directly connected to a good & fast USB 2.0 or USB 3.0 port.

2) Disconnect all other external USB devices.

3) Close all other applications.

4) If logging RAW SIGNAL switch to FAST compression mode or turn off the RAW SIGNAL logging.

5) Reduce the SAMPLE RATE.

![PulseCounter status](image_url)

Fig. 32. PulseCounter status.
If it takes a long time to load an experiment turn off the AUTO-SUMMARY option. If PulseCounter performance is still poor use a faster computer or capture smaller data sets. Performance may also improve if you create experiments with fewer measurements.