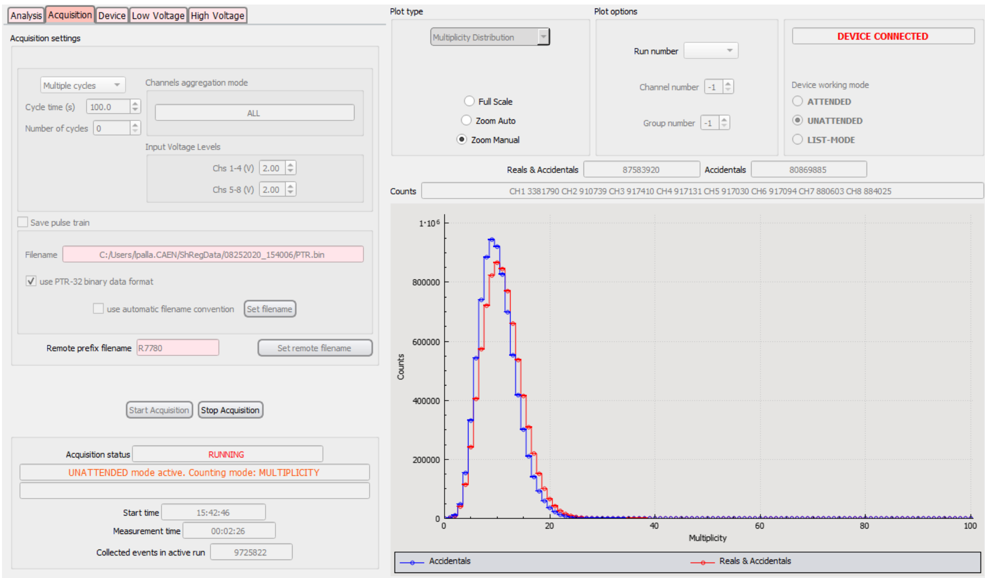
Rev. 2 - January 24th, 2025

CAEN NCC

Software Tool for R7780



CAEN *Tools for Discovery*

User Manual
UM7675

Purpose of this Manual

This document contains the full description of CAEN NCC (Neutron Coincidence Counting) software for the acquisition and control of the R7780 CAEN Shift Register Multiplicity and Time Recorder.

Change Document Record

Date	Revision	Changes
June 8th, 2020	00	Preliminary Release
August 21st, 2023	01	First official release. General update of the User Manual.
January 24th, 2025	02	Modified Sec. **2.2**

Symbols, Abbreviated Terms and Notation

HPGe	High Purity Germanium detector
HVPS	High Voltage Power Supply
MCA	Multi-Channel Analyzer
MDA	Minimum Detectable Activity
OS	Operating System
PC	Personal Computer
PMT	Photo Multiplier Tube
USB	Universal Serial Bus

Reference Documents

[RD1] CAEN. *UM7585 - R7780 Unattended Data Acquisition Module User Manual*.

Manufacturer Contacts

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Limitation of Responsibility

If the warnings contained in this manual are not followed, CAEN will not be responsible for damage caused by improper use of the device. The manufacturer declines all responsibility for damage resulting from failure to comply with the instructions for use of the product. The equipment must be used as described in the user manual, with particular regard to the intended use, using only accessories as specified by the manufacturer. No modification or repair can be performed.

Disclaimer

The information contained herein has been carefully checked and is believed to be accurate; however, no responsibility is assumed for inaccuracies. CAEN SpA reserves the right to modify its products specifications without giving any notice; for up to date information please visit www.caen.it.

Made in Italy

We remark that all our boards have been designed and assembled in Italy. In a challenging environment where a competitive edge is often obtained at the cost of lower wages and declining working conditions, we proudly acknowledge that all those who participated in the production and distribution process of our devices were reasonably paid and worked in a safe environment (while this is true for the boards marked ”MADE IN ITALY”, we cannot guarantee for third-party manufactures).

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1 Introduction

The CAEN R7780 device is a Neutron Coincidence Analyzer and Multiplicity module combining the functions of a Shift Register and a Pulse Train Recorder. The eight single-ended TTL inputs (LEMO) feature independent counting capability. The internal 100 MHz sampling clock fits for high count-rate applications and the on-board intelligence synergy of a FPGA and a Single Board Computer (an ARM CPU running Linux) makes it possible to provide time-stamped lists and the overall neutron counting information (coincidence timing, multiplicity distributions of coincident events, etc.) required for the analysis in Nuclear Safeguards and nuclear material process monitoring.

After the start-up sequence based on a programmable configuration file, the device can collect data without external control on a local non-volatile memory.

The device can also operate in attended mode controlled by an external host computer using a remote network connection through the ethernet port.

2 The CAEN NCC Software

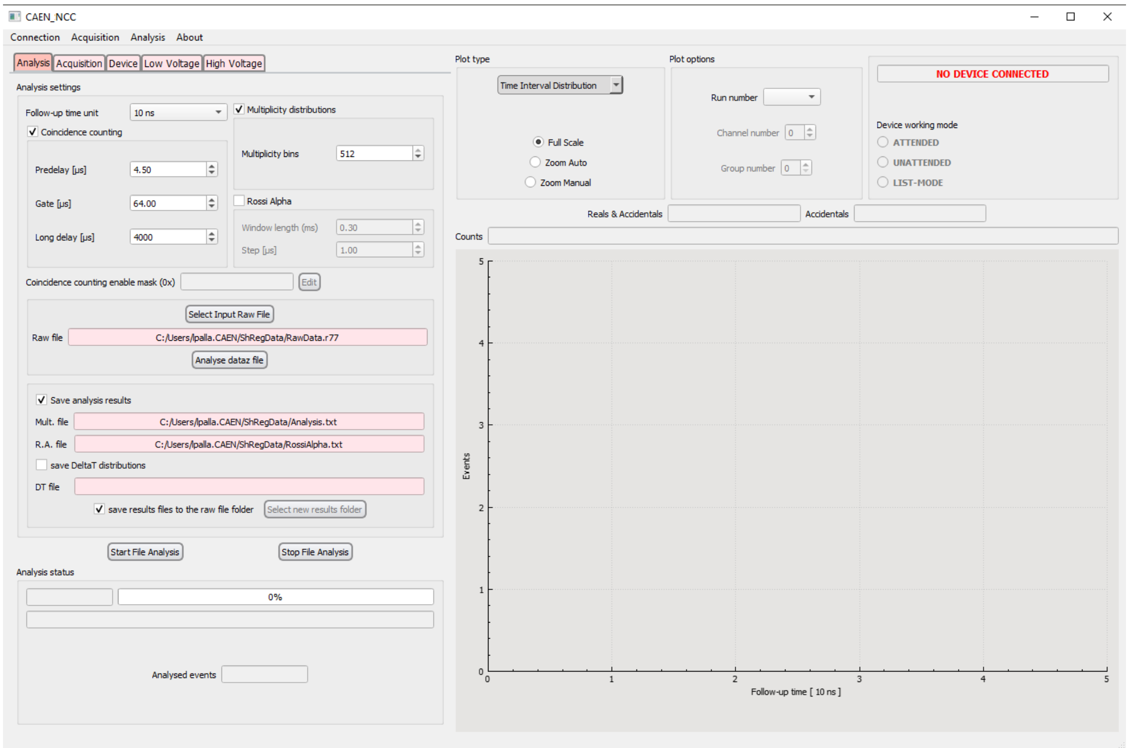


Fig. 2.1: Main window of the CAEN NCC software.

The CAEN NCC software allows to fully configure the R7780 devices and to handle data acquisition according to the device working mode:

- **ATTENDED mode**: the software collects the raw data from the device, reconstructs the pulse train and saves it to binary files locally on the computer for offline analysis. No data is saved to the device SD memory cards. The collected pulse trains can be analysed later. While the data are being collected, the software shows a plot of the follow-up times or a plot of the single channels count rate. This working mode is particularly useful for an initial setup of the device, for test measurements, or for device diagnostics.
- **LIST mode**: the device reconstructs the pulse trains and stores them to PTR-32 binary files on one of the removable SD cards. The collected pulse trains can be downloaded from the memory card and analysed later by the software. The CAEN NCC software can handle data acquisition and when it is active, it shows a plot of the single channels count rate and the total number of counts for each channel.
- **UNATTENDED mode**: the device automatically performs the coincidence and multiplicity analysis of the collected data and saves the results to the SD memory cards as .dataz files. The CAEN NCC software allows to monitor the acquisition status and to see the analysis results while data are being processed by the device. The multiplicity distributions are shown while acquisition is running. The software also allows to stop data acquisition, to modify the device configuration and restart.

The CAEN NCC software can be used also to recall previously stored pulse trains and to execute the coincidence and multiplicity analysis in post-processing, without connecting any device. In this case the single channels data can be analysed individually, in groups, or can be merged together into a single pulse train.

Furthermore, the software allows to reload .dataz files saved by the device, to plot the multiplicity distributions and calculate Singles, Doubles and Triples rates. The main window of the software is shown in **Fig. 2.1**.

2.1 Software Installation

The CAEN NCC software is available for Windows and Linux OS. The package provided for Windows includes the installer file that must be run to start the installation procedure (see **Fig. 2.2**).

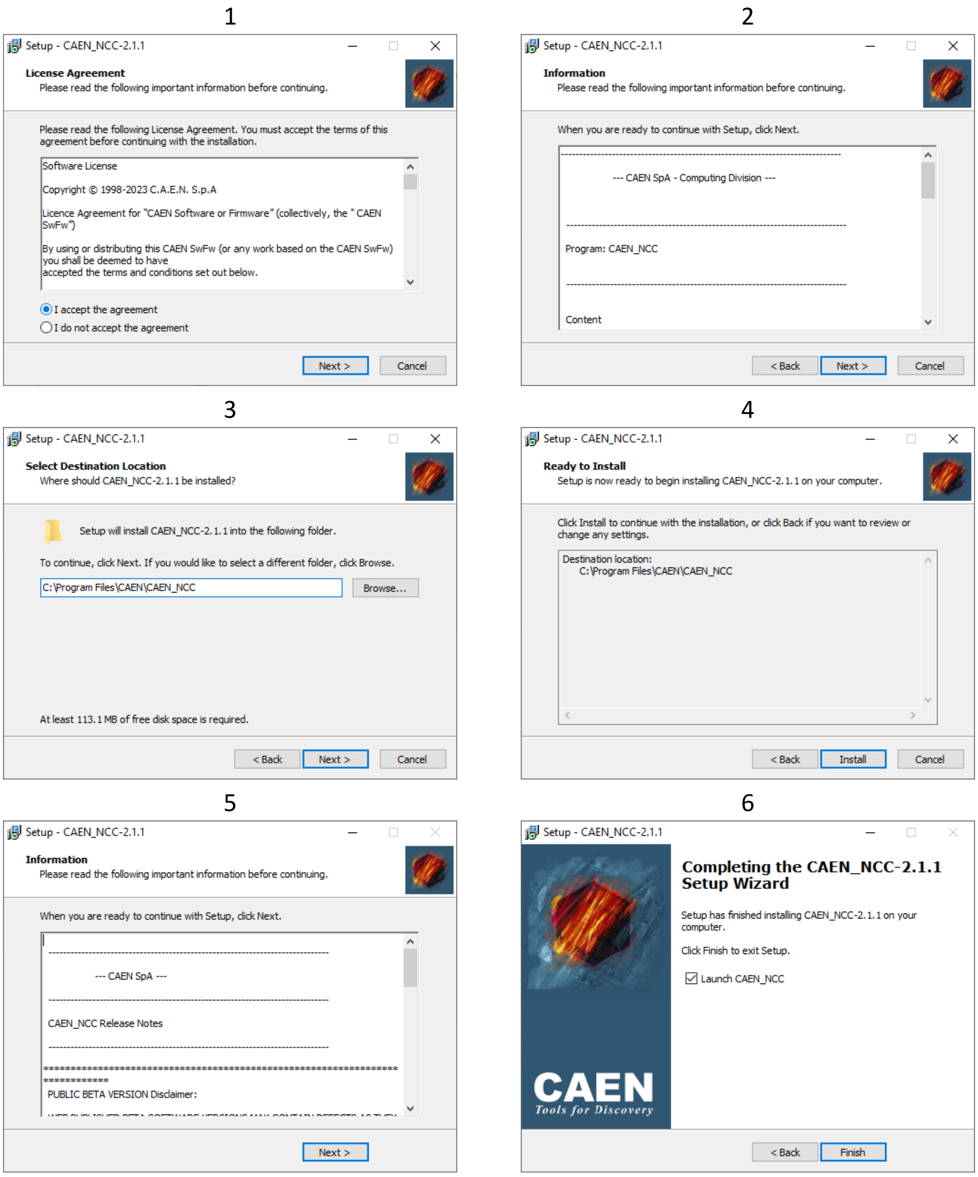


Fig. 2.2: Software installation steps

In case of Linux OS, once extracted the .tar.gz package, the software installation is performed running the command: *sudo sh install.sh*
in the CAEN_NCC_2.1.1 folder. After the installation, the software is launched via the command: *CAEN_NCC*.

2.2 Device connection

To establish a new connection with the device, select *Connection→Connect device* from the main menu.

Two possible connection modes are available: TRUSTED connection mode (see **Fig. 2.3**) allows the user to establish a secure connection; the exchanged TCP packets received from the unit contain an encrypted header that can be decryped only using the public key *R7780Public_key.pem* provided in the installation package. TRUSTED connection prevents possible network security issues. UNTRUSTED connection mode does not use any secure key (see **Fig. 2.4**).

Fig. 2.3: Connection dialog shown when a new trusted connection is established.

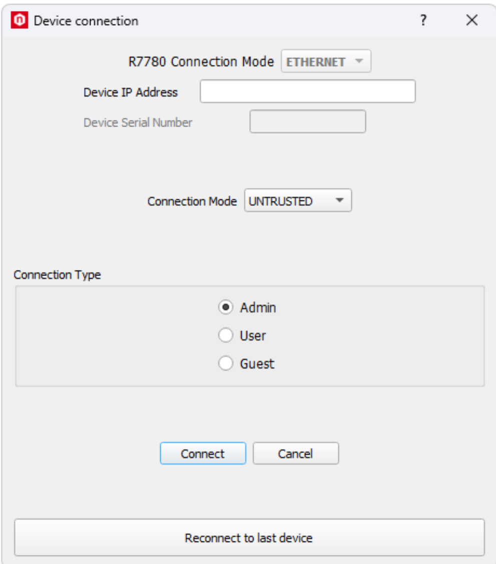


Fig. 2.4: Connection dialog shown when a new untrusted connection is established.

Enter the device IP address in the dedicated section (default IP address is 10.0.0.10, refer to **[RD1]**) and choose between Admin, User or Guest access level:

Admin and *User* login are protected by password, but not the *Guest* login.

A *Guest* is only allowed to check whether data acquisition is running or not, and to have a look at the monitors of the low and high voltage power supplies. The collected data are not visible and all controls are disabled.

A *User* is allowed to monitor the device status and also to have a look at the collected data. **Fig. 2.5** shows the software GUI for a *Guest* and for a *User*. Only *Admin* is allowed to modify the device settings and to start/stop data acquisition.

The *Reconnect to last device* button allows to reconnect to a previously connected device, without entering the connection parameters again.

Fig. 2.5: The CAEN NCC GUI provided for a *Guest* (top) and for a *User* (bottom). In case of a *Guest* access, the acquisition status is shown on the *Acquisition status* section, but the collected data are not visible.

Once a new connection is established, the software shows some key info about the connected device (see **Fig. 2.6**). Afterwards, it automatically checks whether the device is working in UNATTENDED mode and data acquisition is already running. If yes, the software starts monitoring and showing the measurement results (that are also being saved on the removable SD memory cards). The admin user is allowed to take control of the device even when in UNATTENDED mode, in order to adjust some settings, by pressing the *Stop Acquisition* button. When the unattended measurement is stopped, the software allows to re-configure the device and to start a new unattended measurement, or to change the device operating mode. If data acquisition is not restarted and the software is closed, or the connection is closed, the device will restart acquisition automatically if its working mode is set to UNATTENDED. Data acquisition will restart when the *Auto Restart Time* is elapsed or 15 minutes after the connection has been closed.

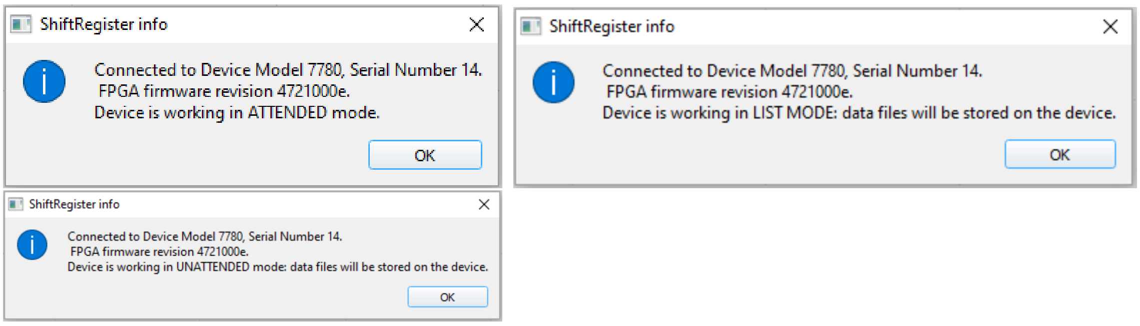


Fig. 2.6: Key info messages shown when a new device is connected.

2.3 Device general settings

Some general device settings are accessible from the *Device* tab (**Fig. 2.7**), which becomes enabled only for an Admin user.

From the *Configuration* section it is possible to save the current configuration or to reload the default configuration.

When any parameter value is modified on the software GUI, the new value is immediately set, but the new configuration is not saved automatically. The *Save current configuration* button allows to manually save the current configuration; the last saved configuration will be reloaded by the device at every start-up. The device configuration is saved automatically when a new data acquisition is started. When the configuration is saved, a copy of the configuration file is created on the SD cards inside the *config* folder and the filename contains the datetime to keep trace of any change in the configuration.

By pressing the *Load default configuration* button it is always possible to reload the factory default configuration, that is stored inside the device internal memory and is never modified.

The *System Time Settings* section allows to read the current system datetime of the device and to adjust it manually, by means of the *Get system DateTime* and *Set system DateTime* button respectively (see **Fig. 2.8**).

The device NTP can be enabled/disabled by checking/unchecking the *NTP* setion. If it is enabled, it is possible to configure the NTP server IP address clicking the *Edit* button, and *NTP manual update* button can be used to force the update of the internal clock and the RTC via the NTP server.

The next section of the *Device* tab is dedicated to the SD card files related settings. If the *Automatic files delete* option is enabled (the checkbox is checked) the device deletes automatically from the SD memory cards the log and data files that are older than a given number of days. This avoids filling the SD memory cards with old files. The minimum age of the files to be deleted can be set by beans of the *Delete files older than* spinbox. When a new day starts, or when the device is switched on, a new check is done to look for old files to be deleted.

When one or both the SD cards must be ejected from the slots in order to be replaced with new ones or only to copy the data files, the *Unmount SD cards* button must be clicked. This allows the safe removal of the memory cards without any data loss: the device stops the active measurement (if data acquisition is running), closes all the files and unmounts the SD cards. When no SD card is present, logging is paused and the device cannot work in unattended or list mode. It can only be operated in attended mode, but logging is disabled in any case. Once the SD cards are back in the slots, the *Restart with SD cards* button must be pressed. The device will restart logging on the SD cards and, if the working mode is UNATTENDED, it will also restart data acquisition using the last saved configuration.

The *Files directory* section contains the current path of the data and log files on the SD cards. It is possible to configure the path by clicking the *Edit* button. The new folder name must start and end with a trailing slash which guarantees that the path is relative to the SD cards (see **Fig. 2.9**). By default the path is set to / (the root folder on the SD cards). If no folder with the given name is present on the SD cards it will be created automatically and data files will be stored inside it.

All the device settings that are related to coincidence and multiplicty analysis and that are relevant only when the device is working in UNATTENDED mode, are collected in a dedicated section in the *Analysis* tab of the CAEN NCC software (see **Fig. 2.10**).

When in UNATTENDED working mode, the device can process the collected data according to three different modalities:

- **Counting mode**: the device counts the input pulses detected by every channel. When a new acquisition cycle is complete, the total number of collected pulses and the number of pulses from every channel are saved to the data files on the SD cards. When this mode is active, the *Coincidence counting* and the *Multiplcity distributions* sections in the *Analysis* tab are not checked.
- **Coincidence_mode**: the coincidence counter is also active. When a new acquisition cycle is complete, also the accumulated Reals, Reals&Accidentals and Accidentals are saved to the data files on the SD cards. When this mode is active, the *Coincidence counting* section in the *Analysis* tab is checked, but not the *Multiplcity distributions* section. It is then possible to set the *Predelay*, *Gate* and *Long Delay* values before starting a new data acquisition. The *Coincidence counting enable mask* section shows the combination of input channels to be used for coincidence counting and allows to configure it. The *enable mask* is a 8-bit hexadecimal number, where every bit corresponds to one of the input channels. If the channel bit is set to 1, that channel is enabled and takes part to coincidence counting. By clicking the *Edit* button, it is possible to modify the channels combination (**Fig. 2.11**).
- **Multiplicity mode**: the multiplicity distributions are also built. When a new acquisition cycle is complete, also the bin contents of the Reals&Accidentals and Accidentals multiplicity distributions are saved to the data files on the SD cards. When this mode is active, both the *Coincidence counting* and the *Multiplcity distributions* sections in the *Analysis* tab are checked. It is then possible to set the number of *Multiplicity bins* of the distributions.

2.3.1 Device working mode

On the top-right of the mainwindow of the software, the current working mode of the connected device is clearly shown (see **Fig. 2.12**). If data acquisition is not running, it is possible to change the operating mode of the device by selecting one among the three working modalities: ATTENDED, UNATTENDED and LIST mode. The software shows a warning message awaiting confirmation from the user before setting the new working mode. The GUI of the software is somehow rearranged on the basis of the new working mode of the device; in particular the plot options are updated. When the working modality is switched to UNATTENDED, the device reloads the last saved configuration, switches on the low and high voltage power supplies automatically, waits for the HV ramp-up to be complete and starts collecting data automatically as expected. The CAEN NCC software waits for the initialization phase to be complete and then starts showing the measurement results. On the contrary, when the working modality is switched to ATTENDED or LIST, the device stops doing any automatic operation and waits for some commands from the software, the software user has the full control of the data acquisition. The following figures (**Fig. 2.13**, **Fig. 2.14**, and **Fig. 2.15**) show some data acquisitions carried out with the device working in the three different working modes.

2.4 Low voltage and high voltage power supplies

The +5 V and +12 V power supplies and the High Voltage channel can be managed and monitored from the *Low Voltage* and *High Voltage* tabs shown in **Fig. 2.16**

The *Low Voltage* tab is divided into two identical sections corresponding to the +5 V and +12 V outputs. The *Output Voltage* sections show the current minitored voltage level of the power supply, that can be switched on/off by means of the *ON* and *OFF* buttons respectively. The *Status* section shows the current status of the power supply (ON, OFF, OFF FAIL). In case of a failure, the power supply is automatically switched off and the *RESET* button can be used to switch it on again. If data acquisition is running in unattended mode, the measurement is automatically stopped.

The *High Voltage* tab provides the *VSet* and *Ramp* fields, that can be used to set the high voltage value and the speed of the HV ramp-up/down respectively. Both the parameters can be set when the HV channel is on or off; when a new value is entered in the corresponding section it is automatically applied. The *HV Status* is printed in the dedicated monitoring section; when HV is off the HV led is gray, it becomes green when HV is ON and red in case an over-voltage or over-current is detected.

2.5 Data Acquisition Control

The *Acquisition* tab, shown in **Fig. 2.17** allows to control data acquisition and to monitor the acquisition status.

The section at the top on the left of the *Acquisition* tab is dedicated to global acquisition control. Two different acquisition modalities are allowed:

- **Infinite single run**: acquisition is started/stopped manually by the user using the *Start Acquisition* and *Stop Acquisition* buttons.
- **Multiple cycles**: acquisition is broken down into a given number of cycles and it is automatically stopped when the total preset time has elapsed (all the planned cycles are finished). The single *Cycle time* can be entered in the corresponding section and the *Number of cycles* can also be set. By setting the number of cycles to 0, the same acquisition cycle is repeated forever until acquisition is stopped manually by the user.

The *Input Voltage Levels* section allows to set the threshold voltage level for input channels 1-4 and 5-8.

The *Save pulse train* option is relevant only when the device working mode is ATTENDED. In this case, if the option is enabled, the CAEN NCC software will save the pulse train to a binary file for later analysis. The path and the name of the generated file is shown in the *Filename* section. By default, the *use automatic filename convention* option is active: the software creates a folder called ShRegData inside the user Home folder on the computer. Inside this main folder a new sub folder is created for every new data acquisition containing the collected pulse train binary file. If the automatic convention is disabled, it is possible to select a different custom filename for the file to be saved. As regards the binary format of the pulse trains, two options are allowed:

- **R7780 CAEN binary format (.r77)**: this specific format includes a 22 bytes header at the beginning of the file, containing some information about the device and measurement configuration. The header contains the following data: device operating mode (1 byte unsigned word), number of cycles of the acquisition (4 bytes unsigned word), acquisition cycle length in seconds (8 bytes unsigned word), channels aggregation mode (1 byte unsigned word), channel or group number (1 byte unsigned word), channel enable mask (4 bytes unsigned word), group enable mask (2 bytes unsigned word), group size (1 byte unsigned word). The header is followed by the pulse train events. For R7780 devices, the channels aggregation mode is CH_ALL and every event is made of the timetag (8 bytes unsigned field), channel number (2 bytes unsigned field) and flags (2 bytes unsigned field). If the acquisition is made of more than one cycle, a unique file is created, but the single runs will still be analysed individually (see also section 2.6).
- **PTR-32 binary format (.bin and .chn files pair)**[1]: this is the format that is also supported by the INCC program[2]. If the acquisition is made of more than one cycle, a diferent pair of files for every cycle is created.

The *Channels aggregation mode* section indicates how the data from the device input channels are managed: the incoming data from all the input channels are merged together and considered as a single pulse train. If the data saving is enabled, the pulse train is saved to a single binary file. The collected events that are saved to file contain also the channel information. For this reason, for an offline analysis, a different channels aggregation can be chosen (see also section 2.6).

The *Remote prefix filename* section is relevant only when the device working mode is UNATTENDED or LIST. It corresponds to the first part of the names of the data and log files that are saved to the SD cards. The first part of the filenames is configurable by the user, and it is followed by the datetime string and the file serial number. By pressing the *Set remote filename* button, it is possible to change the base filename.

In case of errors while acquisition is running, an error message is shown in the *Acquisition status* section. For example, for high input count rates, it may happen that the FIFO of one or more channels goes full. In this case, the software automatically stops the acquisition, because the results will be invalidated due to the data loss.

[1] For the structure of PTR data files see: http://www.iki.kfki.hu/radsec/groups/ptr_en.shtml
[2] For INCC software see https://www.ortec-online.com/products/application-software/incc

2.6 Data Analysis

The *Analysis* section is active when the software starts and is shown in **Fig. 2.18**. When no device is connected, from this section it is possible to load a previously stored pulse train data file and to start the offline analysis.

By default, coincidence and multiplicity counting are enabled, the Rossi Alpha analysis can be activated as an option. Neutron coincidence and multiplicity counting are well established nondestructive assay techniques for nuclear materials based on the detected neutron pulse trains.

The recorded pulse stream from a neutron detector contains a combination of spontaneous fission, induced fission and background neutrons. Neutrons from fission are correlated in time, while this is not so for random background events. To determine whether the neutron events are time-correlated, two equal time periods (*Gates*) are sampled by the analysis routine for every event. The first gate window is opened some time (the *Predelay*) after the neutron detection time and is referred to as the R+A (*Reals + Accidentals*) gate; the second gate, the A (*Accidentals* only) gate is delayed by the *Long Delay* time with respect to the R+A gate. Within counting statistics, the number of accidentals events measured in the A gate is the same as in the R+A gate. Thus the difference between the counts collected in the R+A gate and those collected in the A gate is the desired real coincidence signal R.

The multiplicity counting routine measures also the multiplicity distribution for the R+A and A gates, by determining the number of times each multiplicity occurs in the corresponding gate. At the end of the whole analysis, the Singles (S), Doubles (D) and Triples (T) event rates are calculated by means of the formulae:

$$S = \frac{\sum_{i=0}^{n}(R+A)_i}{T_m} = \frac{\sum_{i=0}^{n}(A)_i}{T_m} \tag{2.1}$$

$$D = \frac{\sum_{i=1}^{n} i(R+A)_i - \sum_{i=1}^{n} i(A)_i}{T_m} \tag{2.2}$$

$$T = \frac{\sum_{i=1}^{n} \frac{i(i-1)}{2}[(R+A)_i - (A)_i] - \frac{\sum_{i=1}^{n} i(A)_i}{S.T_m}[\sum_{i=1}^{n} i(R+A)_i - \sum_{i=1}^{n} i(A)_i]}{T_m} \tag{2.3}$$

where $(R+A)_i$ and $(A)_i$ are the measured multiplicity values for multiplicity i in the two windows, and T_m is the measuring time.

If the Rossi Alpha analysis routine is activated, a new time window is opened after every detected event (the initiating event). The time differences between the initiating event and the next events that follow in the stream is calculated until the time difference is less than the previously set time window. The Rossi Alpha distribution is obtained by binning the time differences according to the *Step* value.

All the parameters involved in the analysis are collected in the *Analysis settings* section and can be adjusted before starting the analysis itself.

If the *Save analysis results* option is checked, the multiplicity counting results will be saved to ASCII files that follow the same format of the INCC Test data files. If the Rossi Alpha analysis is also enabled, a corresponding ASCII file is generated. It is also possible to enable the saving of the *DeltaT* distribution, the distribution of the time difference between the timestamp of every event and that of the next one. The result files are saved, by default, inside the binary file folder (the *save results file to the raw file folder* option is enabled). The destination folder can be changed by unchecking this option or by means of the *Select new results folder* button.

The input file that must be analysed can be chosen by clicking the *Select Input File* button and selecting the file from the storage folder. Supported file formats are the R7780 binary format (.r77) and the PTR-32 binary format.

File analysis can be started/stopped by means of the *Start File Analysis* and *Stop File Analysis* buttons. The pulse train raw file can contain data collected by more than one channel (see also section 2.5). In this case, a dialog is shown (see **Fig. 2.19**) and the software allows to choose the data analysis modality between 3 options:

- **All channels together (CH_ALL)**: data from all channels are merged and analysed together as a unique data stream. A single results file will be generated by the analysis routine.

- **Individual channels (CH_INDIVIDUAL)**: data from every channel will be separately accounted for, single channel distributions are calculated and single channel results files are generated. The results filename will have a _chXX suffix, where XX is the channel number.
- **Grouped channels (CH_GROUPED)**: channels data are grouped and data from a single group of channels are merged together. A result file for every channel group and for every analysis routine is created and the filename will have a _GXX suffix, with XX being the group number. The group size can be set from 2 to 16 channels, scaling by a power of 2.

The software allows the user to repeat the analysis of a given file several times setting different analysis parameters and different channels aggregation modalities.

The raw file can contain data collected during a multi-cycle acquisition. In this case every measurement run is analysed separately, and the results are appended to the results file. At the end of the analysis, the average value of S, D and T rates is also calculated.

While it is in progress, the *Analysis status* section allows to monitor the total number of analysed events and a progressbar indicates the percentage of the analysis that has been completed.

When the analysis is complete, the main results are summarized and shown on a dedicated window, see for example **Fig. 2.20** and **Fig. 2.21**. The results report starts with the event counting results: for every run the total triggers counts and the events readout rate are shown. This first section is followed by the coincidence and multiplicity counting results: for every run the number of analysed events is reported together with the Singles, Doubles and Triples rates and the average multiplicity calculated from the R+A and A measured distributions.

A results report is shown also when an unattended measurement ends; in this case the results are not obtained by the software but are retrieved from the device.

The CAEN NCC software gives the possibility to perform online data analysis while data acquisition is running in ATTENDED mode. To enable the feature, the menu option *Analysis*→*Online Analysis* must be selected. By activating the online analysis, the software will analyse incoming raw data while they are being collected. By default the raw pulse train will not be saved (the *Save pulse train* option is deselected), even though it is possible to re-enable the option.

It must be pointed out that this feature is intended only for testing and for debug purposes and it is not recommended to enable it during routine operation, in particular in long measurements with a high data throughput, because the software performances are reduced. Anyway, it is very useful if used for short measurements to check the analysis parameters and to be sure that the device is collecting data without problems (see for example **Fig. 2.22**).

The *Analyse dataz file* button allows to analyse a .dataz file created by the device on the SD cards. The software shows the coincidence and/or multiplicity analysis results for every run and shows a final analysis report where also S, D and T rates are calculated. For ulti run files the software also shows a simple plot of S, D and T rates versus time (see **Fig. 2.23**). This tool is particularly useful to monitor the rate during long measurement times and to look for peaks in the count rate, or to check for possible problems along the several acquisition cycles.

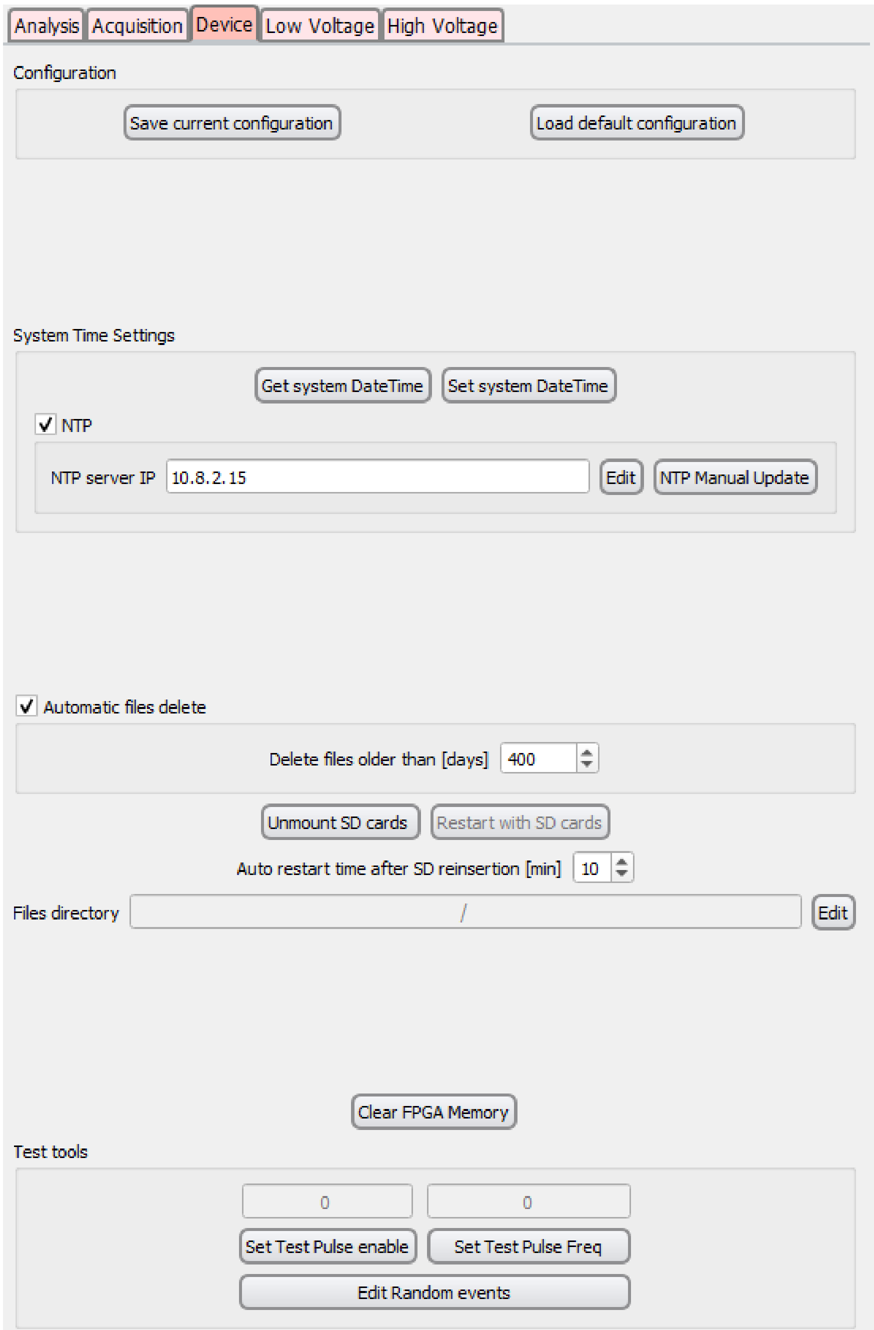


Fig. 2.7: Device tab showing some general device settings.

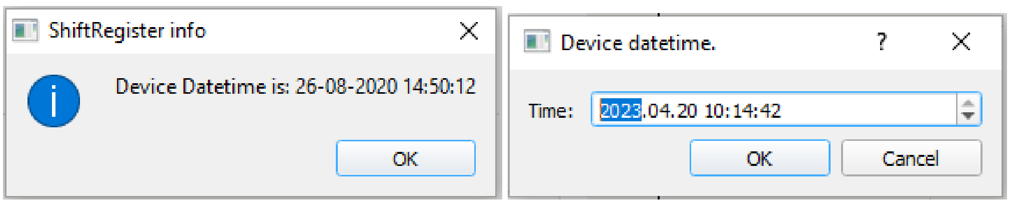


Fig. 2.8: The current system datetime of the connected device shown by the software (left) and the dialog that allows the user to manually adjust the datetime (right).

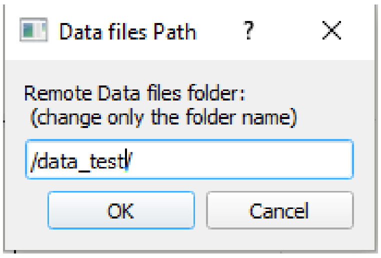


Fig. 2.9: Data file path setting: the new files folder will be set to data_test. Note: the trailing slashes must not be deleted.

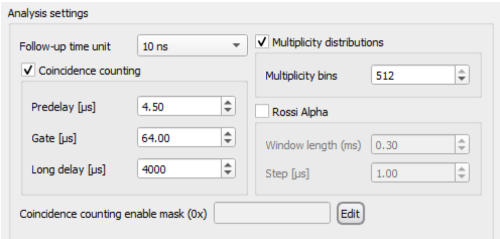


Fig. 2.10: Analysis settings section of the CAEN NCC software.

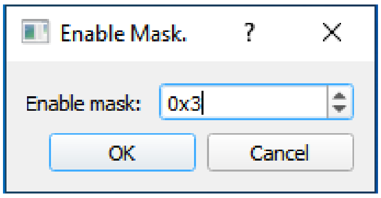


Fig. 2.11: Example of manual editing of the channels enable mask. In this case only channel number 1 and number 2 will be considered by the coincidence counter.

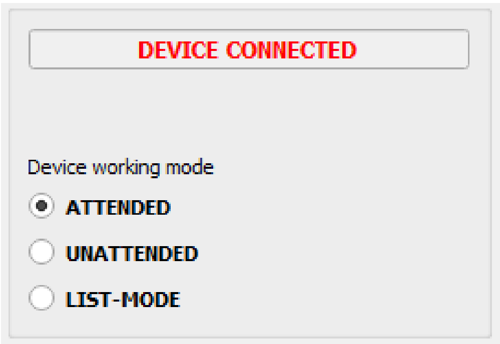


Fig. 2.12: Device working mode section on the software GUI. In this case the connected device is working in ATTENDED mode.

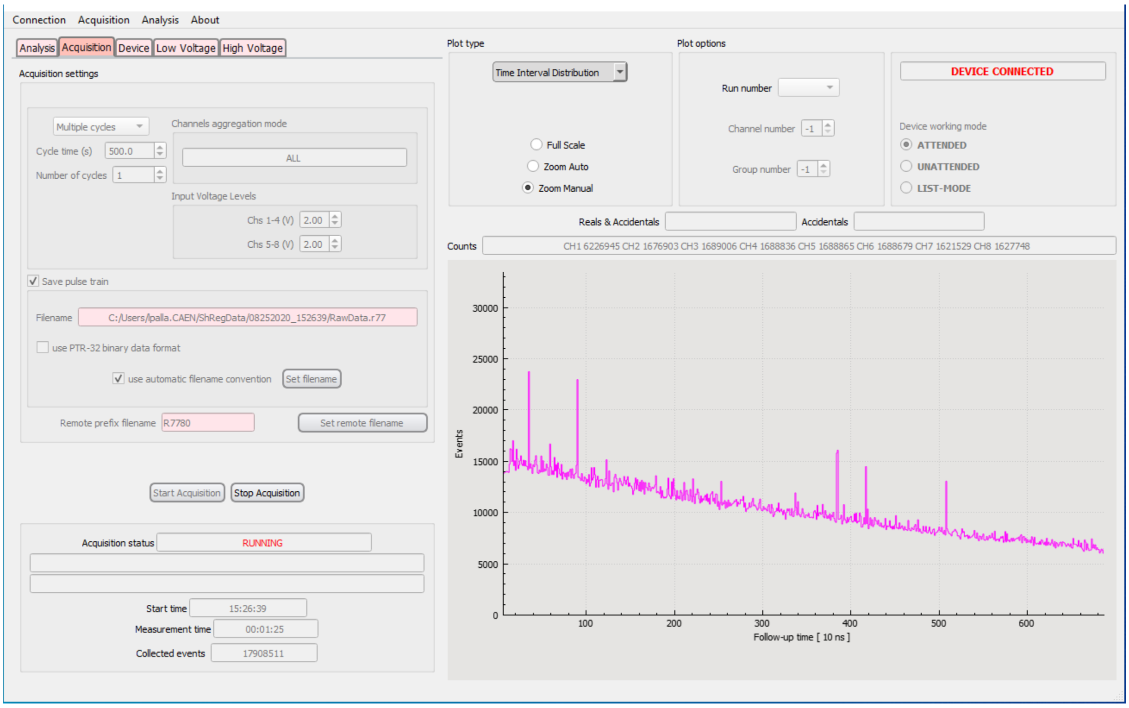


Fig. 2.13: The connected device is working in ATTENDED mode. The measurement time is set to 500 s and acquisition is in progress, the pulse train is being saved inside the default path on the computer running the software. The plot shows the follow-up times distribution and the *Counts* section shows the total number of counts from every channel.

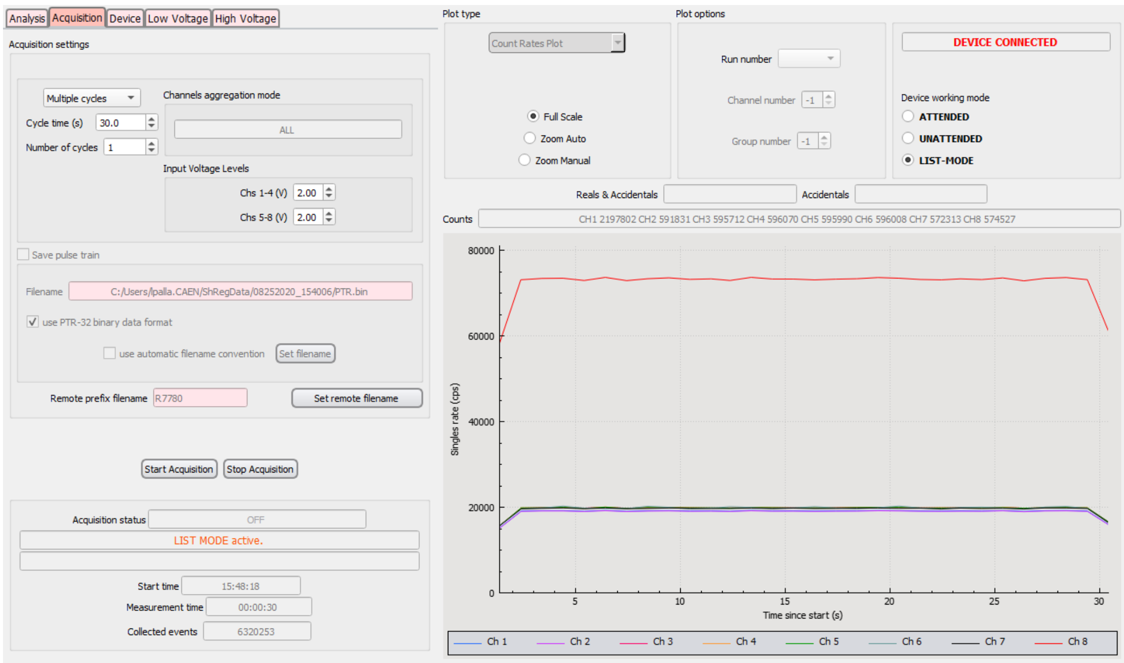


Fig. 2.14: The connected device is working in LIST mode. The measurement time is set to 30 s and the acquisition is complete, the pulse train has been saved on the SD card by the device. The plot shows the count rate of all the input channels and the *Counts* section shows the total number of counts from every channel.

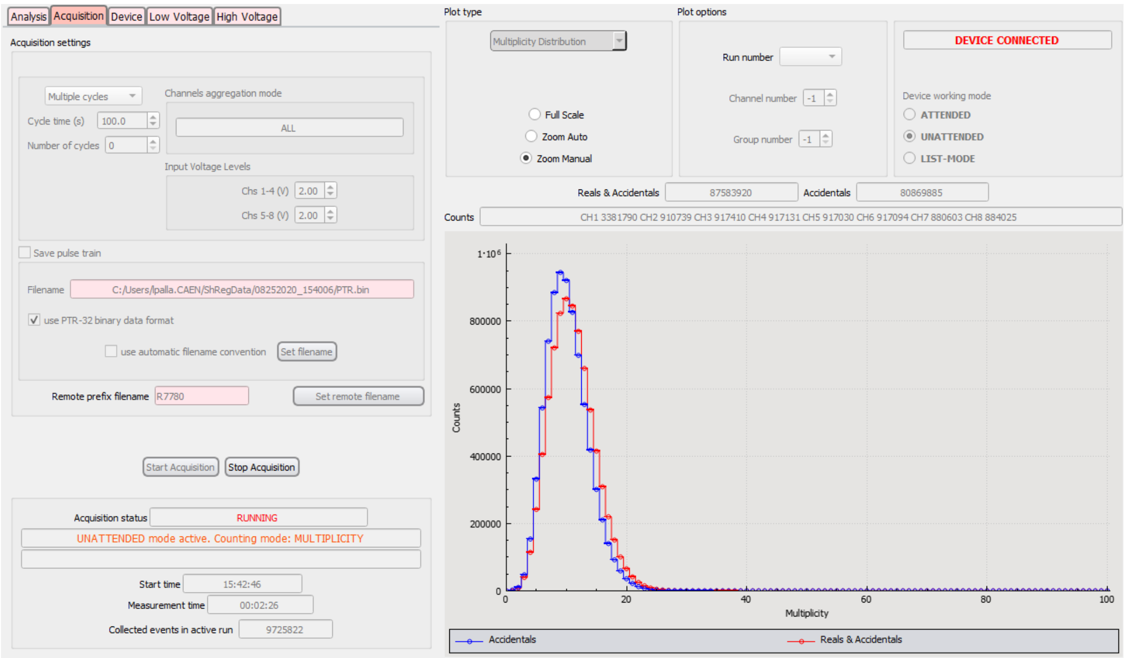


Fig. 2.15: The connected device is working in UNATTENDED mode. The measurement time is set to infinite (the number of cycles is set to 0) and the single cycle time is set to 100 s. Multiplicity counting is active and the results are being saved to the SD cards by the device. The plot shows the multiplicity distributions, the *Counts* section shows the total number of counts from every channel and the *Reals & Accidentals* and *Accidentals* section show the accumulator values.

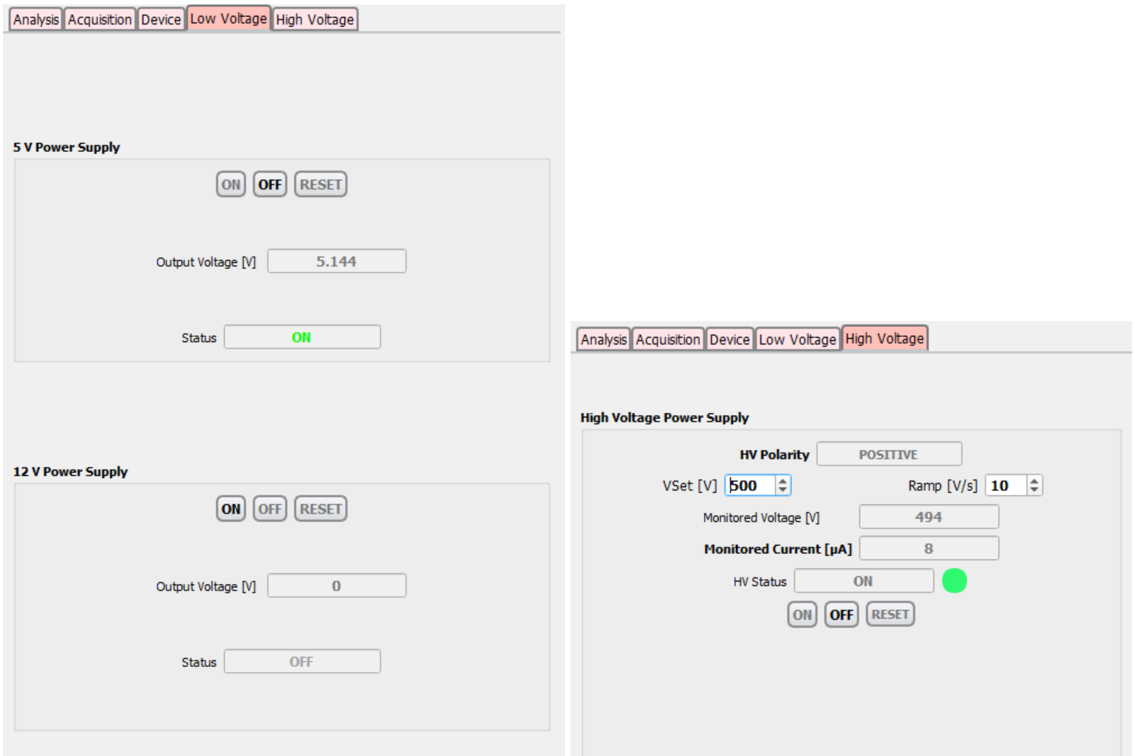


Fig. 2.16: Low voltage (left) and high voltage (right) tabs dedicated to the power supplies. The +5V and the HV power supplies are switched on, while the +12 V is off.

Fig. 2.17: Acquisition tab of the CAEN NCC software.

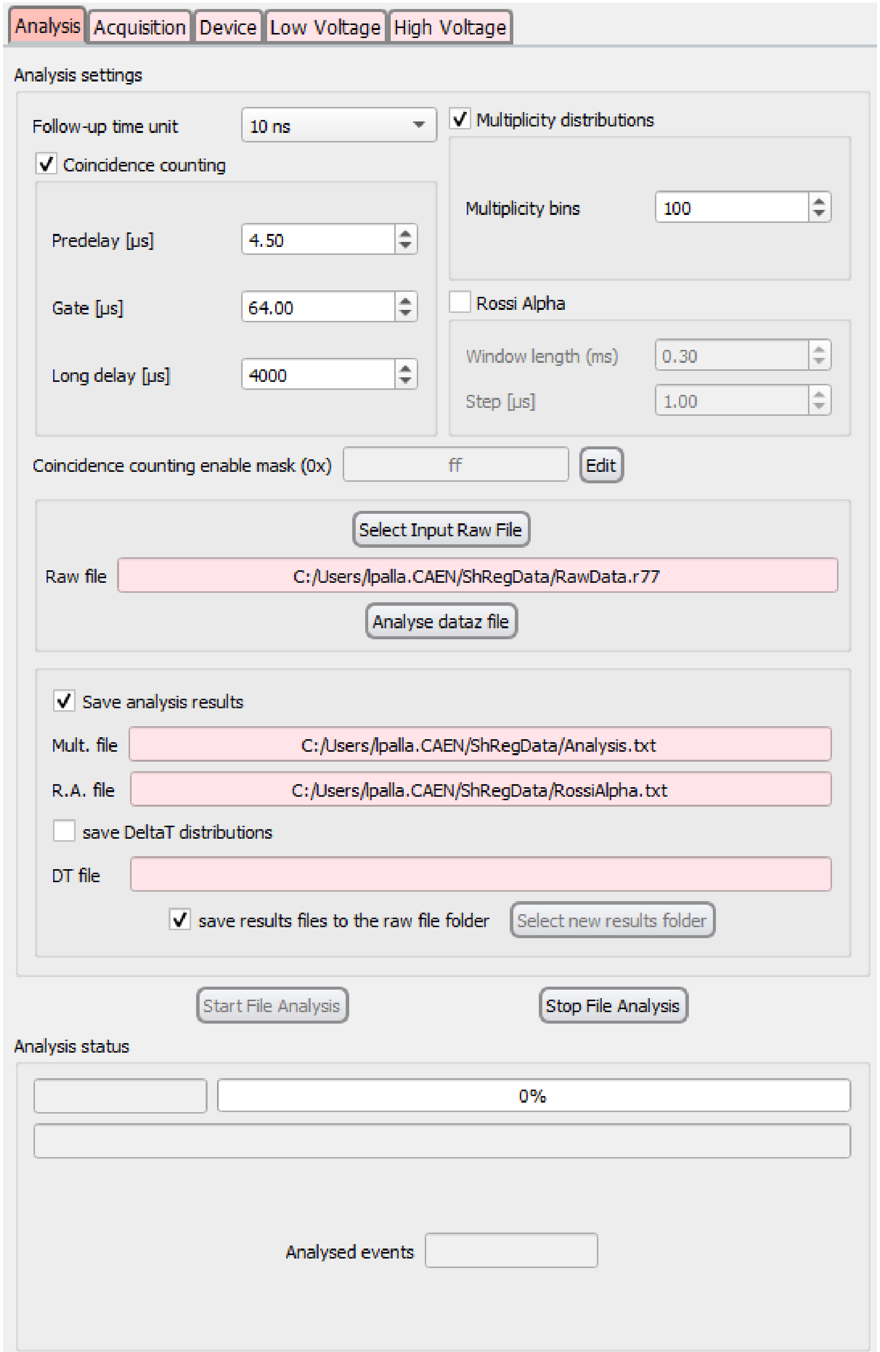


Fig. 2.18: Analysis tab of the CAEN NCC software.

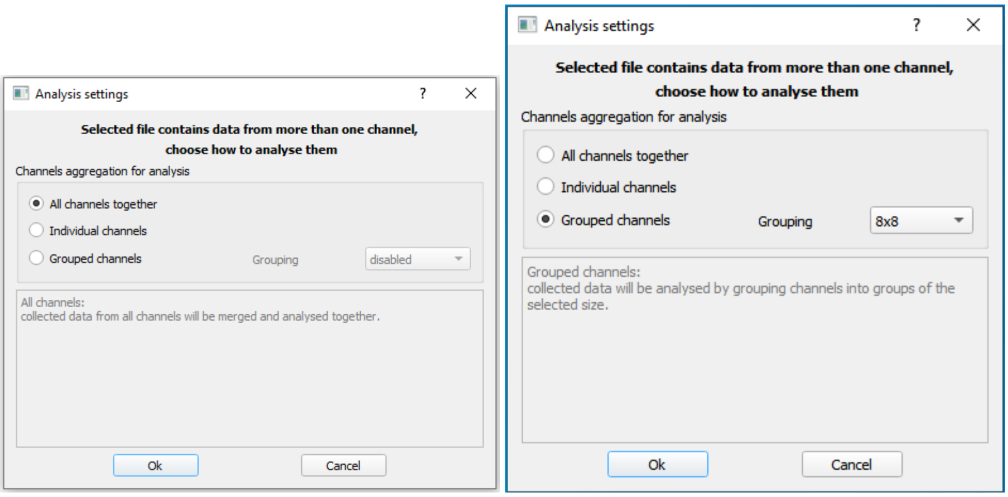


Fig. 2.19: Analysis configuration dialog shown when the file under analysis contains data from more than one channel.

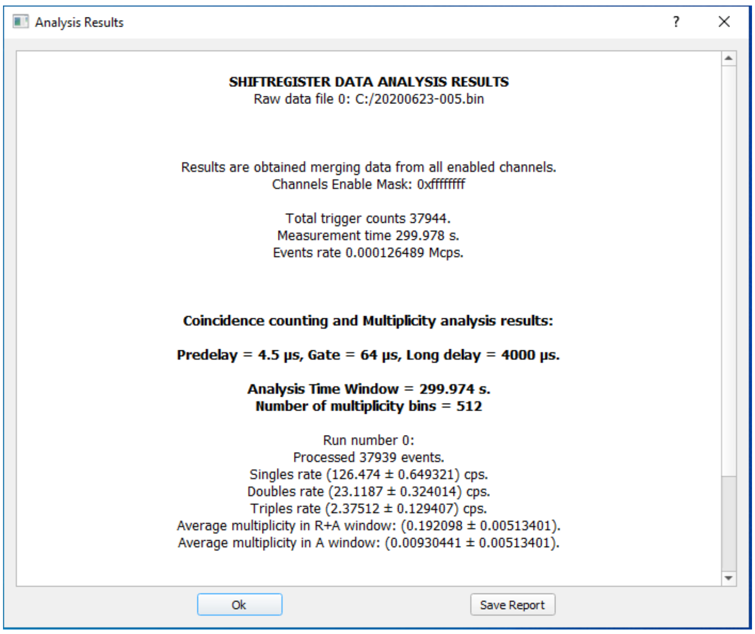


Fig. 2.20: Analysis results report with the summary of the results. For this analysis the channels aggregation mode was set to CH_ALL and the measurement is made of a single run lasting 300 s.

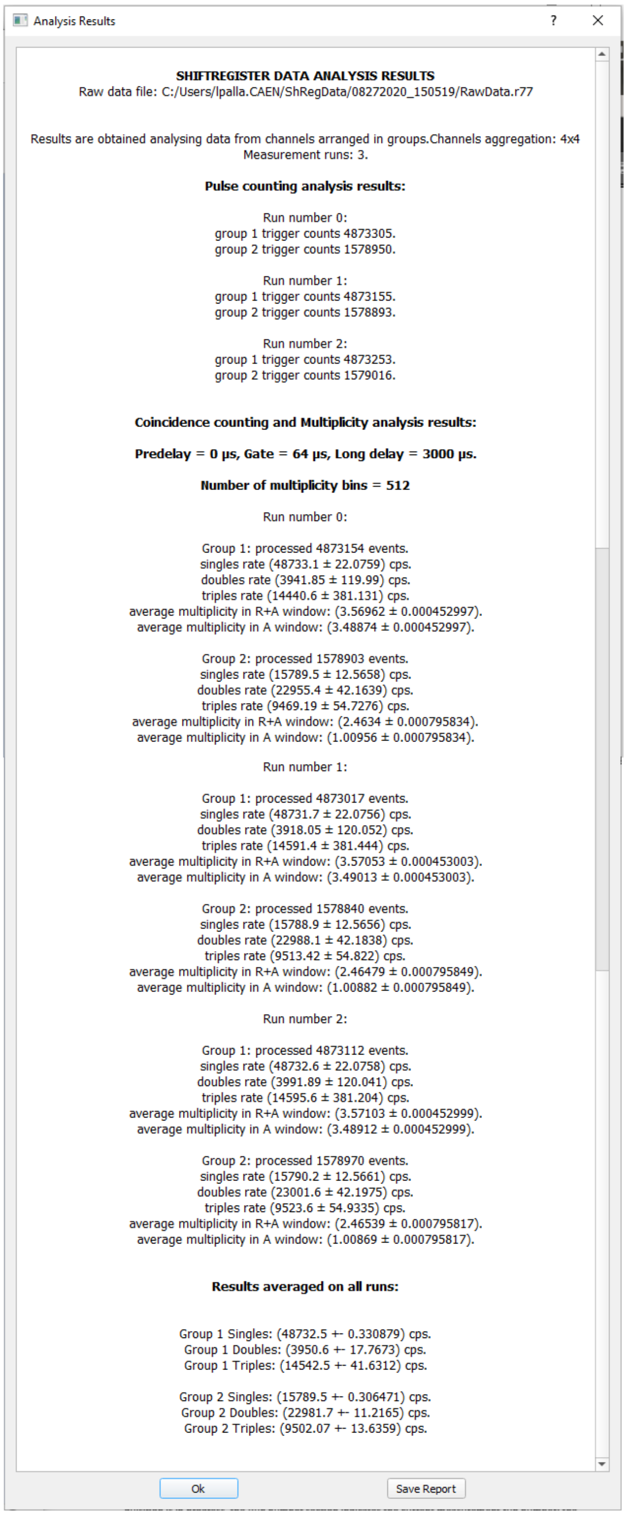


Fig. 2.21: Analysis results report with the summary of the results. For this analysis the channels were arranged into groups of size 4 and the measurement was made of 3 runs lasting 100 seconds each. Results are reported for every run and for every channel group. In the last section the average values for S, D and T in the 3 runs are reported.

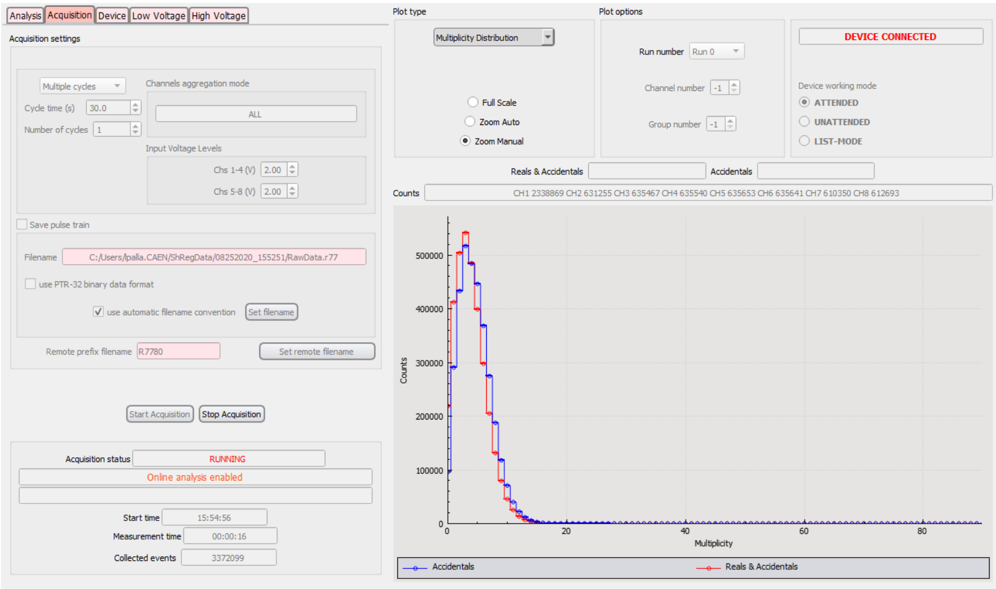


Fig. 2.22: Online analysis running while the device is acquiring data. The resulting multiplicity distributions are clearly visible. This indicates that the collected data are ok, so the real acquisition can be started and the pulse train can be saved.

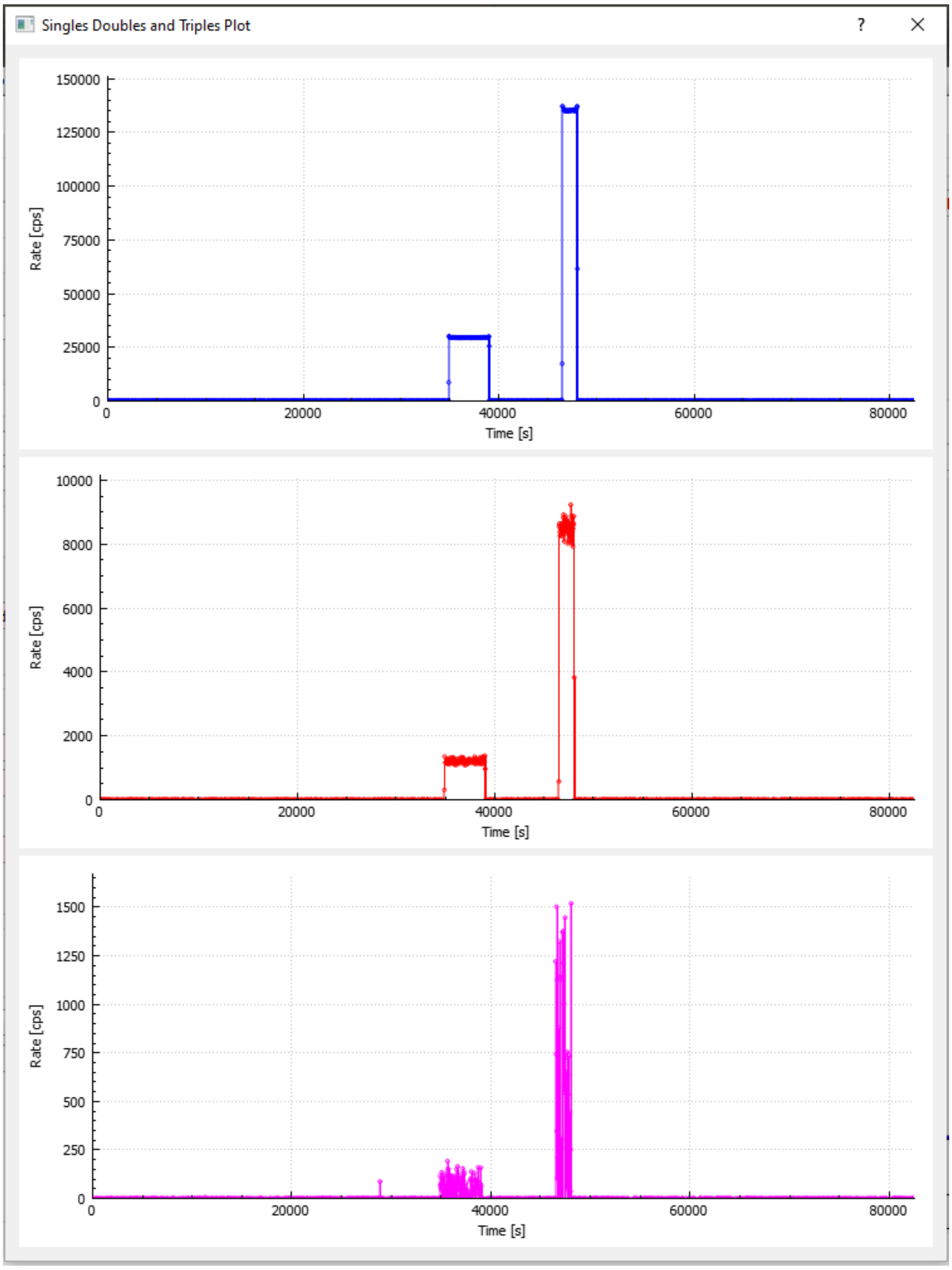


Fig. 2.23: Plots of the Singles, Doubles and Triples rates as a function of time obtained after the analysis of a dataz file made of about 2750 cycles of 30 s each. Two peaks in the count rates can be seen.

2.7 The Plot Section

The section on the right of the main window of the CAEN NCC software is dedicated to the plot of the distributions obtained by the analysis routine. The *Plot type* section is used to select and identify the kind of distribution to be loaded for the plot. The possible plots are:

- **Time Interval Distribution**: this is the distribution of the time differences between one event and the following one inside the pulse train. A histogram is filled with the ΔT values and the width of a single bin of the histogram corresponds to the *Follow-up time unit* setting in the *Analysis* tab (by default 10 ns). Two examples are shown in **Fig. 2.24**.

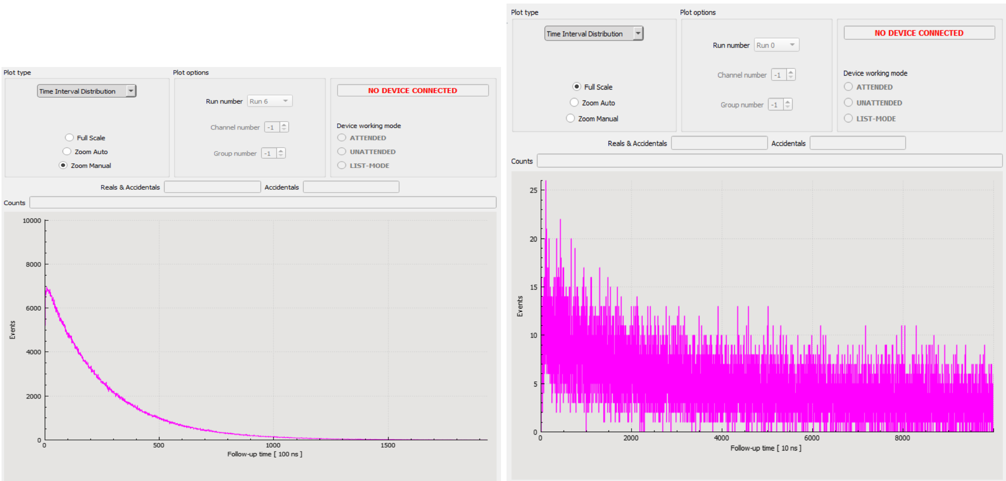


Fig. 2.24: Two different examples of time interval distributions.

- **Multiplicity Distribution**: in this case the distributions of the multiplicity of events detected in the R+A and the A gates are shown in different colors. Every bin of the histogram corresponds to an increasing multiplicity value. Two plot examples are shown in **Fig. 2.25**.

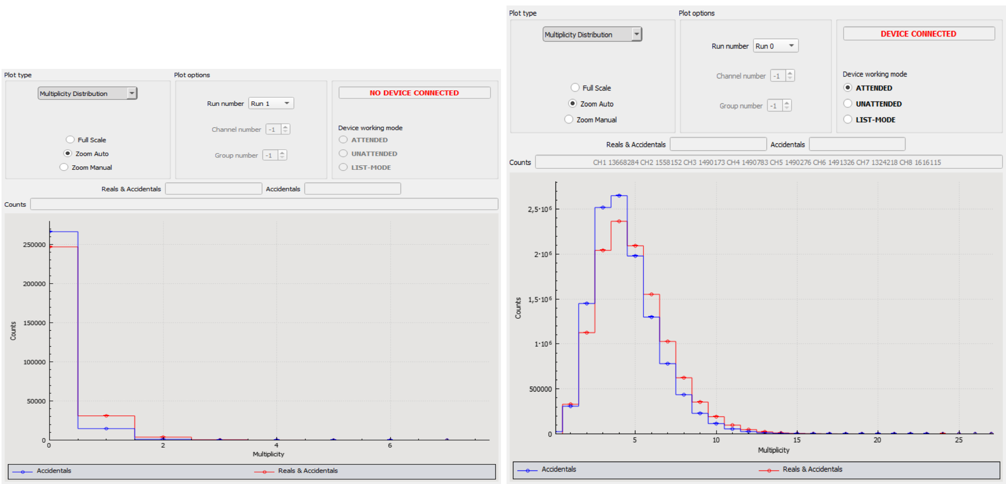


Fig. 2.25: Two different examples of multiplicity distributions. The R+A distribution is shown in red, the A didtribution is superimposed on the same plot in blue. The plot on the left is relative to an offline analysis, the one on the right corresponds to a data acquisition in ATTENDED mode with the option *Online Analysis* enabled.

- **Rossi Alpha Distribution**: this is the distribution in time of events that follow after an arbitrary chosen starting event. The time window used for the measurement can be defined in the *Analysis* tab as also the bin size (the *Step*). Two examples are shown in **Fig. 2.26**.

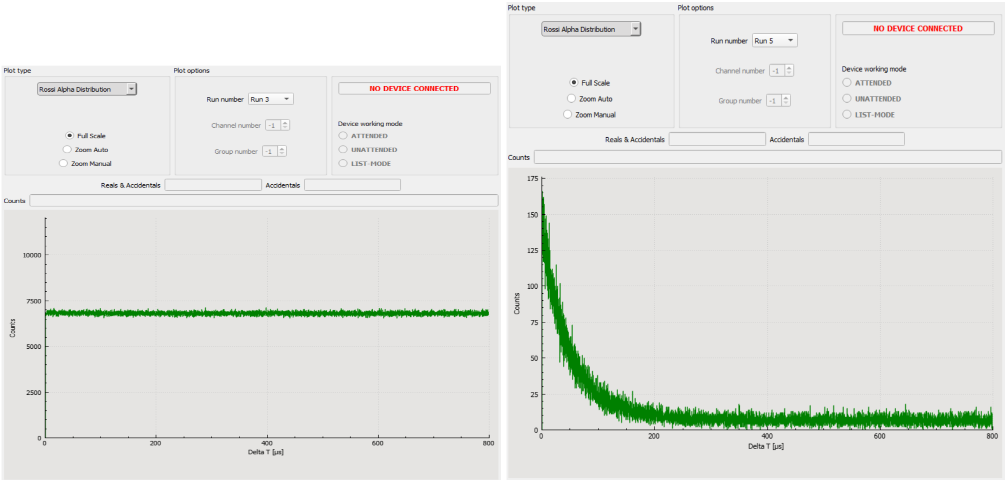


Fig. 2.26: Two different examples of Rossi Alpha distributions. On the left only random uncorrelated events are present while on the right the distribution shows an exponential decay due to the presence of correlated events from fission.

- **Count Rates Plot**: this is the plot of the input count rate of the device input channels (the Singles rate) and can be activated only when a device is connected and is working in ATTENDED or LIST mode. The maximum plot time window is 300 seconds, so if the acquisition length is longer, the windows shifts and the oldest points are deleted from the graph. One example is shown in **Fig. 2.27**.

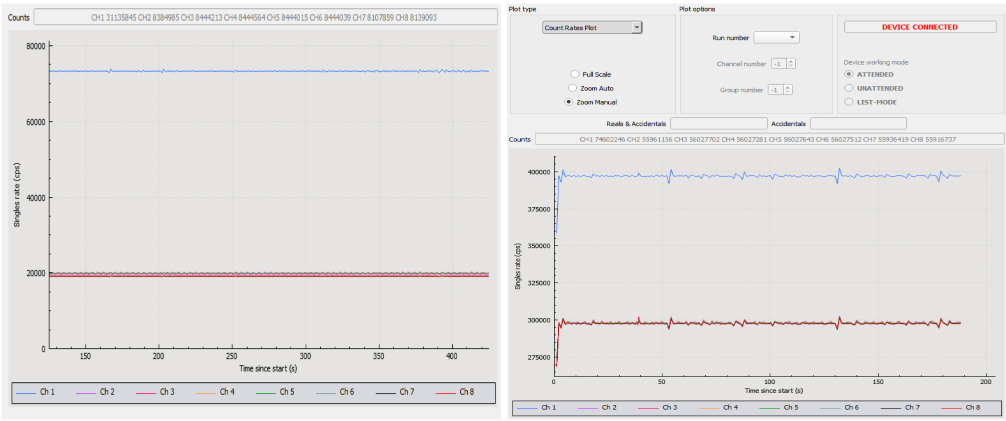


Fig. 2.27: Examples of a Count rate plots shown when acquisition is running in ATTENDED mode.

The *Plot options* section summarizes the possible settings for the plot; some sections are disabled/enabled according to the plot type and the acquisition status (when a device is connected), see **Fig. 2.27**.

- When a device is connected, the plot behaves in a different way according to the device working mode. In ATTENDED mode the plot shows the measured time interval distribution or the count rate graph while acquisition is running and it is automatically updated. In UNATTENDED mode the plot shows the measured multiplicity distributions that are also periodically updated. If a multi-cycle acquisition is in progress, the *Run number* section indicates the current measurement run number; the distributions are relative to the current run.
- When the offline analysis of a binary file is in progress, the *Plot Type* section is enabled and it is possible to select the distribution to plot. The plot is refreshed automatically while the analysis is going on. As in the previous case, the plot is relative to the current measurement cycle that is being analysed and the *Channel number* and *Group number* sections are enabled according to the chosen channels aggregation mode. When the analysis is completed, also the *Run number* section becomes

enabled and it is possible to replot the distributions relative to a given run from the list of runs present in the file.

- When the online analysis is running, it is still possible to select the kind of distribution to plot, but the run number will be always the current one.

In the plot section some extra info are also shown when a device is connected and data acquisition is running: the *Counts* lineedit contains the number of input pulses detected by every channel during the current acquisition cycle, the *Reals&Accidentals* and the *Accidentals* lineedit contain the values of the accumulators (if the coincidence mode is enabled).

2.7.1 Interacting with the plot

It is always possible to interact with the plot to zoom in and out the x and y axis scale. In the *Plot Type* section it is possible to select the zoom option for the plot:

- **Full Scale**: the horizontal axis is shown in full scale and the vertical axis is automatically rescaled to fit the plot data.
- **Zoom Auto**: the horizontal axis zoom is optimized in order to fit the plot data in the best way, the vertical axis is automatically rescaled.
- **Zoom Manual**: automatic axis rescale is disabled and the user is allowed to zoom in and out by positioning the mouse pointer on one of the axis and using the mouse wheel. By holding the *Ctrl* key on the keyboard and selecting a rectangle on the plot itself, both the plot axis ranges will be resized to the selected rectangle.

2.8 The HV Plateau Tool

The HV Plateau Tool allows to measure the count rate as a function of the HV value. The plateau is characteristic for ^{3}He proportional counters and represents the region of greatest stability for detection operation, i.e. the least variation in detection efficiency for small variations in HV power. The Tool can be opened selecting Acquisition->HV Plateau from the menu, the widget is shown in **Fig. 2.28**.

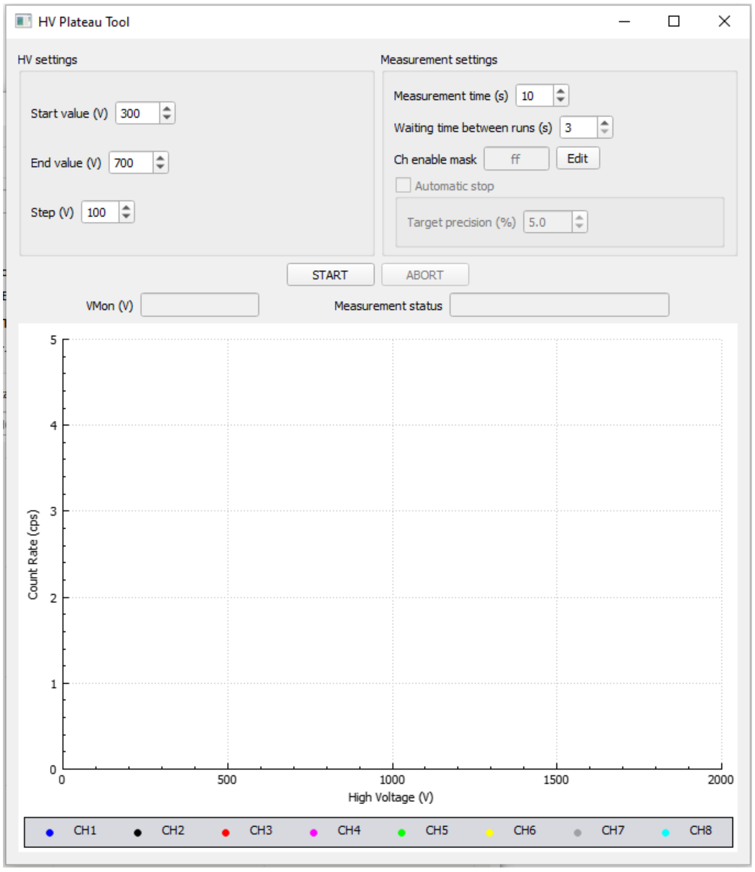


Fig. 2.28: HV Plateau widget.

The current settings stored in the device are loaded and shown on the popup widget. The user can adjust the HV *Start value*, the *End value* and the voltage *Step*. Depending on the selected values, the planned acquisitions will be executed automatically. The length of every acquisition is given by the *Measurement Time*. The *Waiting time* between runs should be set by the user taking into account for the HV ramp value and the HV stabilization time. It is also possible to select the input channels that will be considered for the measurement, by editing the *Ch enable mask*. For every active channel a new graph will be shown on the plot in a different color. The tool can be used to perform this measurement when the connected R7780 device is working in ATTENDED or in UNATTENDED mode and it is managed in a different way depending on the working modality.

- In ATTENDED mode, the CAEN NCC software manages the consecutive acquisition runs and the HV settings automatically, saving also the collected timestamps to files, and calculates the count rate for every active channel. When a new run is complete, the plot is updated with the new count rate results and the software waits the planned time before starting the next run. A waiting message shows the remaining time before the next run will start (see **Fig. 2.29**).

  A final report is shown at the end of the HV plateau measurement, see for example **Fig. 2.30**.

  Furthermore, in this modality, the option *Automatic stop* becomes active and allows to stop a single measurement run when a preset counting statistics precision has been reached. The precision is calculated considering the total counts from all active channels.

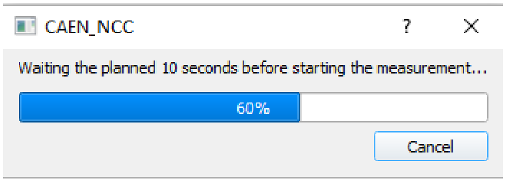
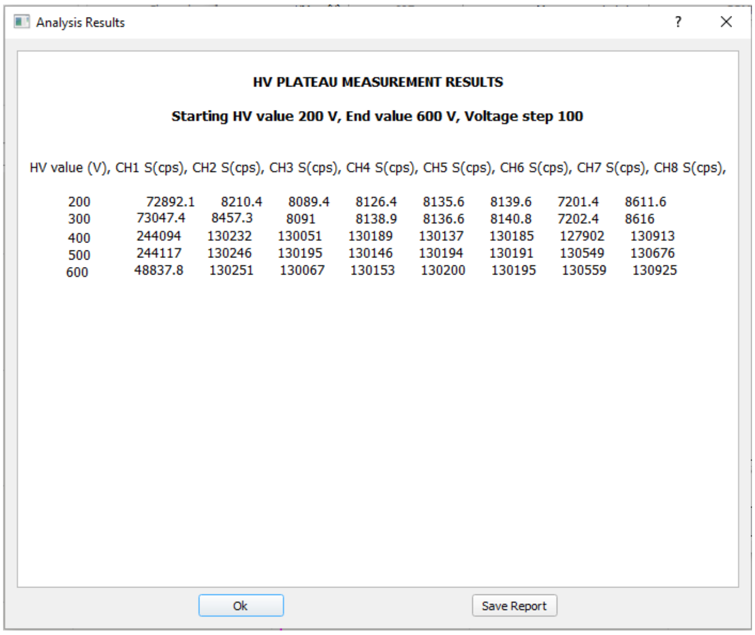


Fig. 2.29: Waiting dialog shown between one measurement run and the next.


Analysis Results

HV PLATEAU MEASUREMENT RESULTS

Starting HV value 200 V, End value 600 V, Voltage step 100

HV value (V)	CH1 S(cps)	CH2 S(cps)	CH3 S(cps)	CH4 S(cps)	CH5 S(cps)	CH6 S(cps)	CH7 S(cps)	CH8 S(cps)
200	72892.1	8210.4	8089.4	8126.4	8135.6	8139.6	7201.4	8611.6
300	73047.4	8457.3	8091	8138.9	8136.6	8140.8	7202.4	8616
400	244094	130232	130051	130189	130137	130185	127902	130913
500	244117	130246	130195	130146	130194	130191	130549	130676
600	48837.8	130251	130067	130153	130200	130195	130559	130925

Ok Save Report

Fig. 2.30: HV Plateau results shown by the CAEN NCC software at the end of the measurement.

- In UNATTENDED mode, the R7780 device carries out the planned acquisitions automatically, manages the HV channel ramp, and stores the counting results to dataz files on the SD memory cards. This new counting modality is called *HVPlateau* and is a new option together with *Counting*, *Coincidence* and *Multiplicity*. The CAEN NCC software in this case simply monitors the current acquisition run and updates the plot when a new run is completed.

  When a new device is connected to the software, if the HVPlateu counting mode is already active, it is not possible to start a standard acquisition; this counting mode can be managed only by the HV Plateau Tool. If the user tries to start a normal data acquisition from the *Acquisition* tab, a warning message is shown and allows to disable the HVPlateau mode (see **Fig. 2.31**).

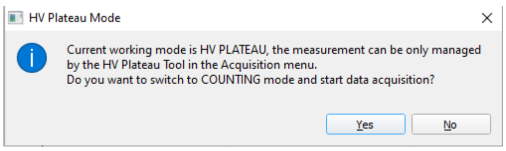


Fig. 2.31: Warning message shown by the CAEN NCC software if the *Start Acquisition* button is clicked when the HV-Plateau counting mode is active.

Fig. 2.32 shows one example of the measured HV Plateau curves when the measurement is complete. The traditional method for determining the operating HV is to select a value about 50 V above the knee on the plot. By double clicking on a point inside the plot in the region of gratest stability, it is possible to automatically apply the corresponding HV value on the x axis.

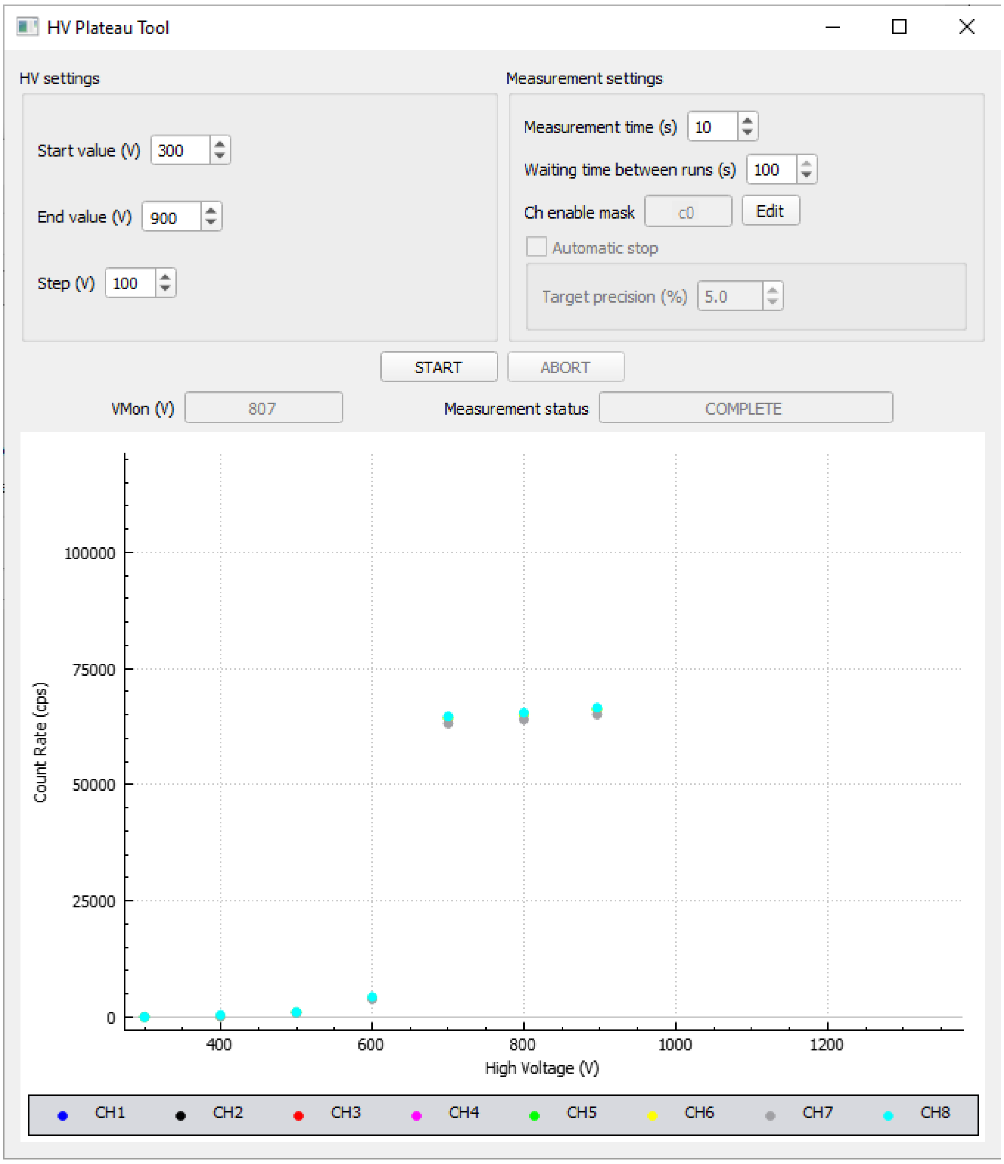


Fig. 2.32: Example of HV Plateau measurement. Only channels 7 and 8 were active. The final HV value that has been chosen is 807 V (*VMon (V)* on the widget).

3 Technical Support

To contact CAEN specialists for requests on the software, hardware, and board return and repair, it is necessary a MyCAEN+ account on www.caen.it:

https://www.caen.it/support-services/getting-started-with-mycaen-portal/

All the instructions for use the Support platform are in the document:


CAEN
Tools for Discovery

SAFETY, STORAGE AND SETUP INFORMATION

PRODUCT SUPPORT AND SETUP INFORMATION

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ASSISTENZA E RIPARAZIONE DEL PRODOTTO

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A paper copy of the document is delivered with CAEN boards.
The document is downloadable for free in PDF digital format at:

https://www.caen.it/wp-content/uploads/2022/11/Safety_information_Product_support_W.pdf

User Manual UM7675
CAEN NCC - Software Tool for R7780

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