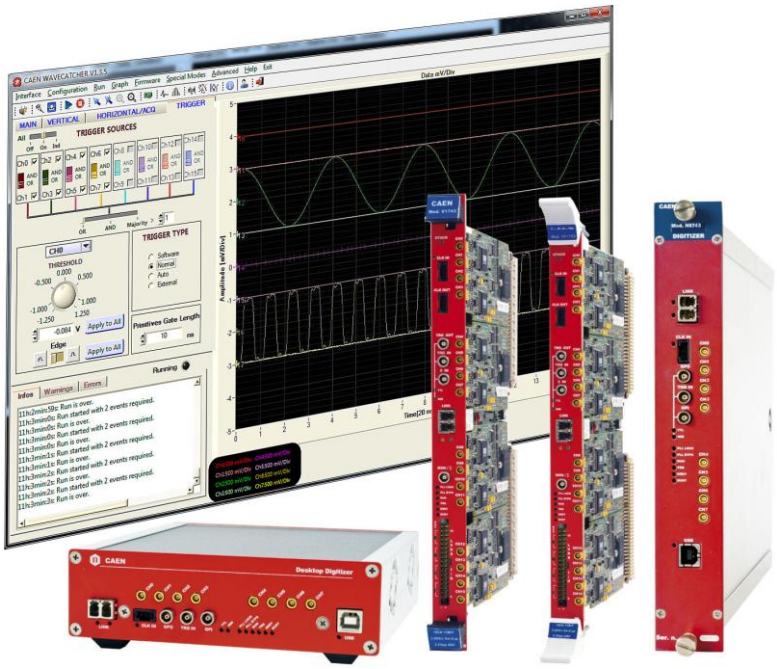
CAEN
Tools for Discovery

Electronic Instrumentation



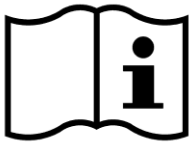
User Manual UM2754

WaveCatcher

Advanced Software Tool for 743 Digitizer Family

Rev. 4 – May 26th, 2025

Purpose of this Manual



This User Manual contains the full description of the WaveCatcher software for CAEN 743 digitizer series, basing on the software release v1.8.5.

Change Document Record

Date	Revision	Changes
April 10th, 2015	00	Initial release.
July 29th, 2015	01	Updated Chap. **2**.
February 3rd, 2016	02	Replaced **Fig. 6.1**. Updated Sec. **Saving Data**. Added Sec. **Primitives Gate Length**, Sec. **Max Num Evts / Read Block**.
November 22nd, 2022	03	Fully revised. Added new CAEN Bridges and multi-board support. Major updates: Chap. **5**, Chap. **7**, Sec. **9.1.3**. Added Sec. **5.1.5**, Sec. **5.1.6**, Sec. **7.3.4**, Sec. **7.3.5**, Sec. **7.6.4**, Sec. **7.8**.
May 26th, 2025	04	Fixed the output binary format in Sec. **11.2.3**.

Symbols, Abbreviated Terms, and Notations

DC	Direct Current
LED	Light Emitting Diode
OS	Operating System
PC	Personal Computer
USB	Universal Serial Bus

Reference Documents

[RD1] UM2750 – V1743 User Manual

[RD2] UM2748 – DT5743 User Manual

[RD3] UM8789 - CAENWaveDemo_x743

[RD4] GD2783 – First Installation Guide to Desktop Digitizers & MCA

[RD5] GD2512 – CAENUpgrader QuickStart Guide

[RD6] UM1935 – CAENDigitizer User & Reference Manual

[RD7] UM1934 - CAENComm User & Reference Manual

[RD8] UM4413 - A2818 Technical Information Manual

[RD9] UM3121 - A3818 Technical Information Manual

[RD10] DS7799 - A4818 Adapter Data Sheet

[RD11] UM8305- V4718-VX4718 Bridge User Manual

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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 (this is true for the boards marked "MADE IN ITALY", while we cannot guarantee for third-party manufactures).

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1 Introduction

WaveCatcher is a software for Microsoft Windows OS which has been developed by CNRS/IN2P3/LAL as a user-friendly interface putting the acquisition power of the fast CAEN 743 Digitizer family at the fingertips of users concerned with the simultaneous and synchronized acquisition of transient waveforms from multiple channels systems. The selected format recalls the familiar operation of a Digital Oscilloscope, although the target digitizer is not a real digital oscilloscope.

WaveCatcher software supports the CAEN 743 Digitizer family in different form factors, as indicated in **Tab. 1.1**.

Any detail on the digitizer hardware, specifications and principle of operation, can be found in the digitizer User Manuals free available on CAEN website **[RD1][RD2]**.

Board Models	Description
DT5743	8 Ch. 12 bit 3.2GS/s Switched-Capacitor Digitizer: 3 events/ch (1kS/event), EP3C16, SE
V1743	16 Ch. 12 bit 3.2GS/s Switched-Capacitor Digitizer: 3 events/ch (1kS/event), EP3C16, SE
VX1743	16 Ch. 12 bit 3.2GS/s Switched-Capacitor Digitizer: 3 events/ch (1kS/event), EP3C16, SE

Tab. 1.1: List of supported boards

Note: The NIM version for the 743 digitizer series is not available.

2 Installation

WaveCatcher software is provided with Windows® support only.

Before installing the WaveCatcher software:

- **Make sure that** you properly installed CAEN hardware in the set-up (refer Digitizer, Controller or Bridge User Manual) and the communication cable (optical or USB).
- **Make sure that** you installed the driver for your OS and communication link (Sec. **2.1**).
- **Make sure that** you installed the required third-party software, NI LabWindows™/CVI Run-Time Engine 2009 or higher.

Note: find the latest LabWindows™/CVI RNE version available on National Instruments web site.

To properly run the WaveCatcher software, the third-party NI LabWindows™/CVI Run-Time Engine (2009 or higher) must be installed on the operating system of the host PC.

2.1 Drivers

To deal with the hardware, CAEN provides the drivers for all the different types of physical communication interfaces featured by the specific digitizer and compliant with Windows OS:

- **USB-2.0 Drivers for NIM/Desktop boards** are downloadable on CAEN website (www.caen.it) at the digitizer web page (**login required**) in:

  "Downloads" page -> "Software" tab

- **USB-2.0 Drivers for V1718/VX1718** (obsolete) **and V3718/VX3718** CAEN Bridges, required for VME boards interface, are downloadable on CAEN website (www.caen.it) at the V1718/VX1718 and V3718/VX3718 web pages (**login required**) in:

  "Downloads" page -> "Software" tab

- **USB-3.0 Driver for the A4818 Adapter** (CONET to USB3), required only for Windows OS, is downloadable on CAEN website (www.caen.it) at the adapter web page (**login required**) in:

  "Downloads" page -> "Software" tab

- **Optical Link** Drivers are managed by the A2818 PCI card or the A3818 PCIe card. The driver installation packages are available on the CAEN website at the A2818 or A3818 page (**login required**) in:

  "Downloads" page -> "Software" tab

Some explicative hardware connection options are described in the table below together with the required drivers.

HW connection chain	Comm. Link	Drivers
PC → **USB** → DT57xx/N67xx	USB-2.0	Driver for DT/NIM digitizers
PC → **USB** → V1718/V3718 → **VME** → V17xx	USB-2.0	Driver for V1718/V3718 Bridge
PC → **USB** → V4718 → **VME** → V17xx	USB-3.0	No driver required
PC → **PCI** → A2818 –> **CONET** → DT57xx/N67xx/V17xx	OPT LNK	Driver for A2818 Controller
PC → **PCIe** → A3818 → **CONET** → DT57xx/N67xx/V17xx	OPT LNK	Driver for A3818 Controller
PC → **PCI** → A2818 → **CONET** → V2718/V3718/V4718 → **VME** → V17xx	OPT LNK	Driver for A2818 Controller
PC → **PCIe** → A3818 → **CONET** → V2718/V3718/V4718 → **VME** → V17xx	OPT LNK	Driver for A3818 Controller
PC → **USB** → A4818 → **CONET** → DT57xx/N67xx/V17xx	USB-3.0	Driver for A4818 Adapter
PC → **USB** → A4818 → **CONET** → V2718/V3718/V4718 → **VME** → V17xx	USB-3.0	Driver for A4818 Adapter
PC → **ETH** → V4718 → **VME** → V17xx	ETHERNET	No driver required

Tab. 2.1: Driver association examples

2.2 Libraries

The user is not required to install the CAEN libraries as they are included in the WaveCatcher setup and locally installed by the software.

WaveCatcher relies on CAEN libraries, which are a set of middleware software required by CAEN software tools for a correct functioning. These libraries, including also demo and example codes, represent a powerful base for users who want to develop customized applications for the digitizer control (communication, configuration, readout, etc.):

1. **CAENDigitizer** is a library of C functions designed specifically for the Digitizer family and it supports also the boards running the DPP firmware. The CAENDigitizer library is based on the CAENComm which is based on CAENVMELib, as said above.
2. **CAENComm** library manages the communication at low level (read and write access). The purpose of the CAENComm is to implement a common interface to the higher software layers, masking the details of the physical channel and its protocol, thus making the libraries and applications that rely on the CAENComm independent from the physical layer. Moreover, the CAENComm is based in turn on CAENVMElib and it requires the CAENVMELib library (access to the VME bus) even in the cases where the VME is not used.

2.3 Software

WaveCatcher installation package is available for free download on CAEN web site (www.caen.it) at the software product web page (**login required**).

The step-by-step installation procedure is reported in this section on a Window 10 host PC. In case of a different supported Windows OS, the displayed dialogue boxes, indications, or operations may slightly differ from the following instructions.

1. Unpack the WaveCatcher packet and sun the software installer file.

2. As the software Setup Wizard starts, click on **[Next]** key to continue.

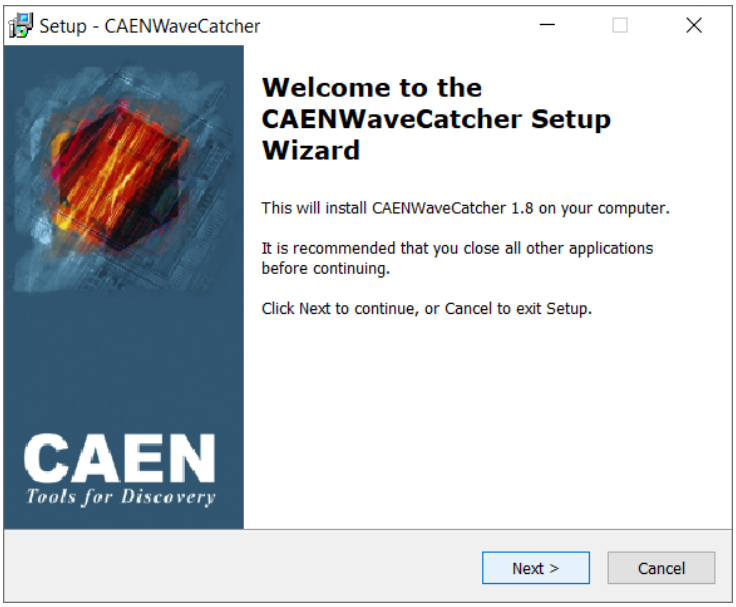


Fig. 2.1: Setup Wizard first step

3. Carefully read the software license information, then check the license agreement box and click on **[Next]** key to continue.

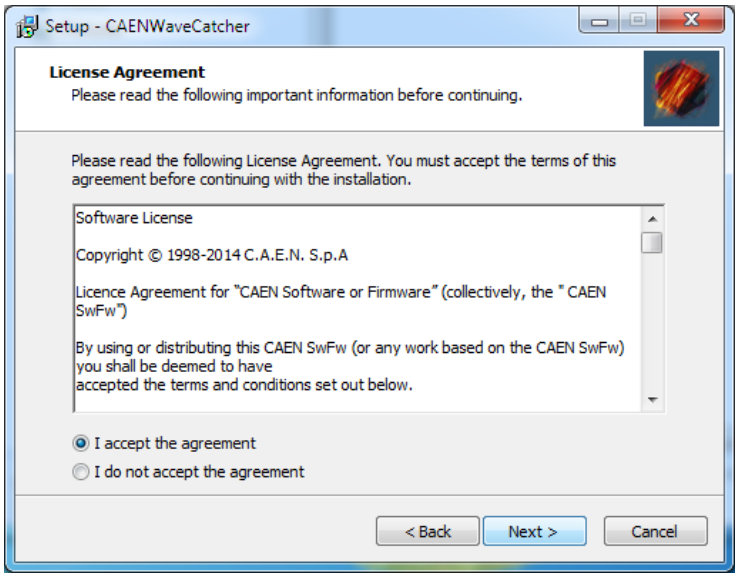


Fig. 2.2: License agreement step

4. Optionally, select the destination folder for the software installation by the **[Browse]** key, then click on **[Next]** key to continue.

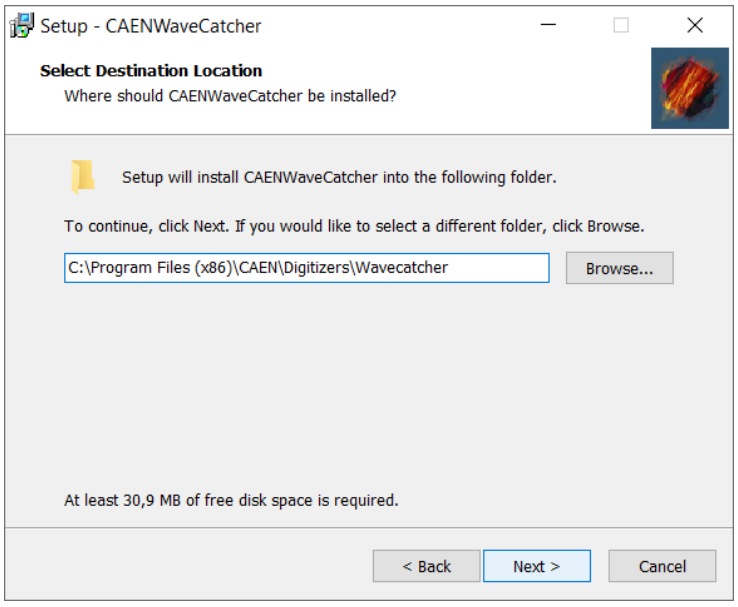


Fig. 2.3: Destination selection step

5. Optionally, select the Start Menu folder for the software shortcuts by the **[Browse]** key, then click on **[Next]** key to continue.

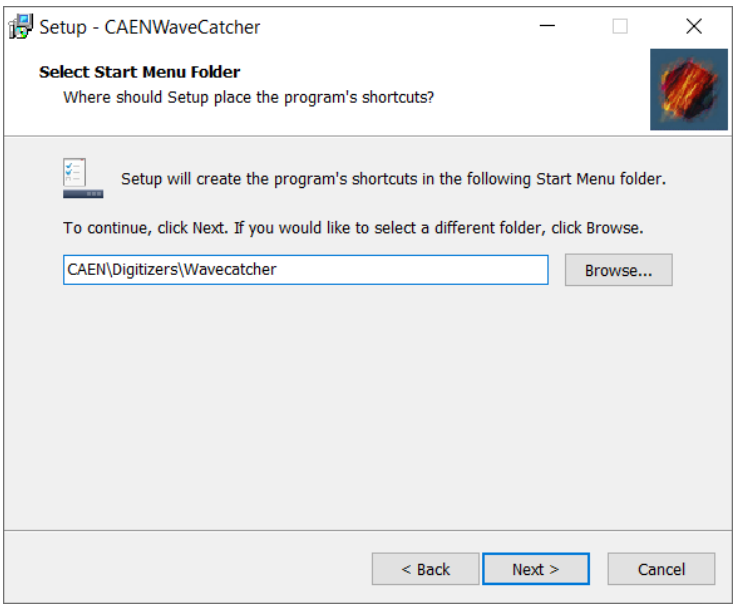


Fig. 2.4: Shortcuts folder selection

6. Click on **[Install]** key to start the WaveCatcher installation

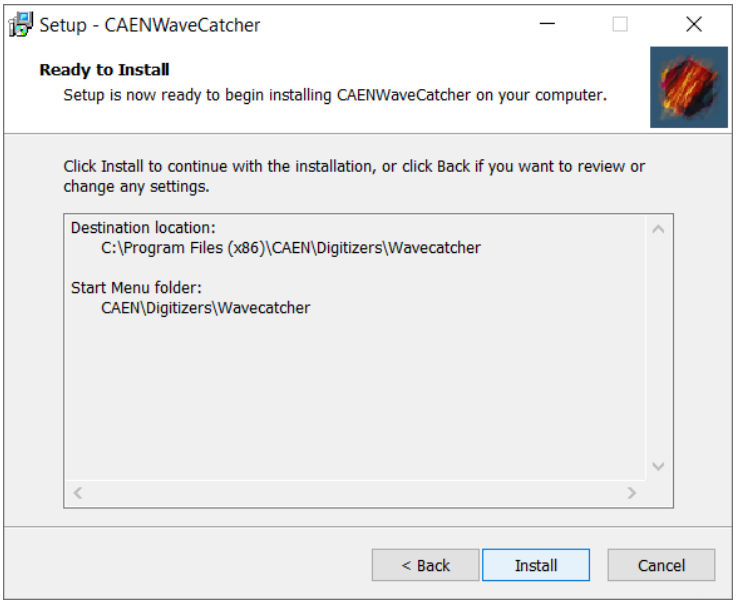


Fig. 2.5: Software installation

7. At first installation, the software requires the Microsoft Visual C++ 2015 Redistributable x86. Click the **[Install]** key to install it.

8. Finally, select whether to directly launch the software or not and click on **[Finish]** key to exit the Setup Wizard.

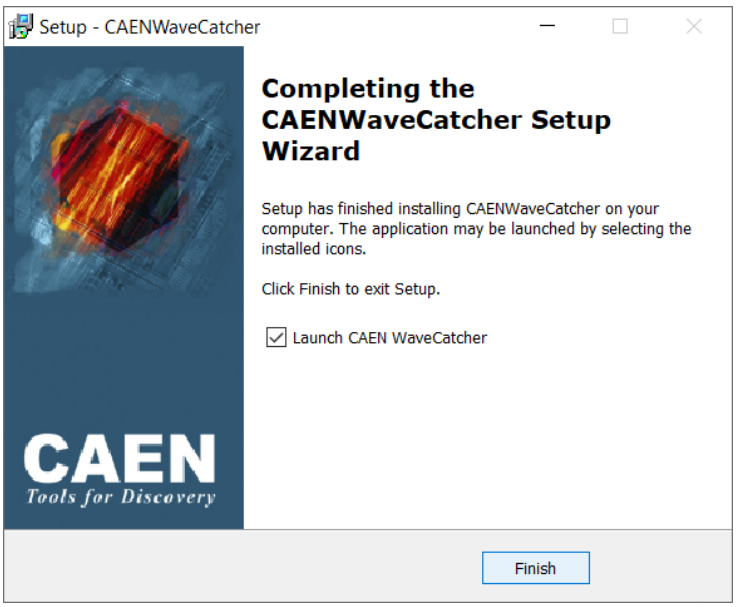


Fig. 2.6: Setup Wizard final step

3 Run

WaveCatcher software can be run optionally by:

- checking the dedicated box at the end of the installation Setup Wizard (on first installation only);
- clicking on the shortcuts generated in the Windows Start Menu folder;
- double-clicking on *CAENWavecatcher.exe* file in software destination directory.

4 Uninstallation

To uninstall the WaveCatcher software from the operating system on the host PC, it is recommended to:

- go to the *Control Panel* of the Windows OS;
- click on *Programs* or on *Program and Functionalities* section (according to the Windows® distribution);
- select *CAENWavecatcher 1.8* amongst the listed software applications;
- uninstall the software.

5 Initialization

5.1 Board Connection Dialog Box

Launching the WaveCatcher software, the Board Connection dialog box appears (**Fig. 5.1**).

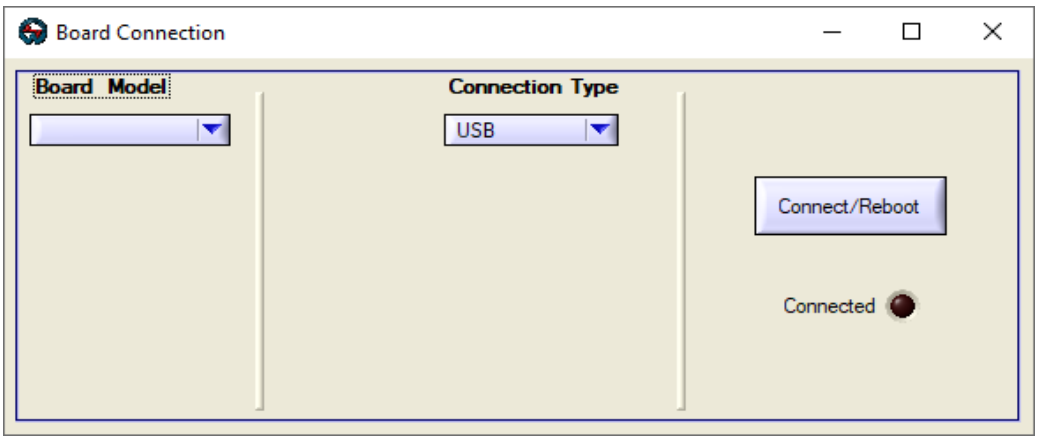


Fig. 5.1: Board Connection dialog box

Board Model	Connection Type	Parameters		
DT5743/N6743	USB	Link N°		
	OPTICAL	LinK N°	Conet Node	
	USB_A4818	Conet Node	PID N°	
V1743	USB	Link N°	VME Base Address	
	OPTICAL	Link N°	Conet Node	VME Base Address
	USB_A4818	Link N°	PID N°	VME Base Address
	ETH_V4718	Conet Node	IP Address	VME Base Address
	USB_V4718	PID N°	VME Base Address	

Tab. 5.1: Connection options and parameters

5.1.1 Board Model

The *Board Model* must be set according to the form factor of the target board: *DESKTOP/NIM* or *VME*.

5.1.2 Connection Type

The Connection Type must be set according to used communication link.

HW connection chain	Connection Type
PC → **USB** → DT5743	USB
PC → **USB** → V1718/V3718 → **VME** → V1743	
PC → **PCI/PCIe** → A2818/A3818 –> **CONET** → DT5743/V1743	OPTICAL
PC → **PCI/PCIe** → A2818/A3818 → **CONET** → V2718/V3718/V4718 → **VME** → V1743	
PC → **USB** → A4818 → **CONET** → V2718/V3718/V4718 → **VME** → V1743	USB_A4818
PC → **USB** → A4818 → **CONET** → DT5743/V1743	
PC → **USB** → V4718 → **VME** → V1743	USB_V4718
PC → **ETH** → V4718 → **VME** → V1743	ETH_V4718

Tab. 5.2: Connection type association

5.1.3 Link N°

The *Link Number* is an incremental index (default value is 0) associated to the communication link, USB or Optical. In case of more than one link is simultaneously active, it permits to manage the communication to multiple CAEN digitizers connected to the host PC.

- **USB connection:** the link numbers are assigned by the PC as soon as the digitizer is connected to the computer by the USB cable; the first device connected takes 0, the second takes 1 and so on: there is not a fixed correspondence between the USB port on the computer and the link number.
- **Optical connection:** the link number indicates which link of the A2818 or A3818 controller is used; the link index starts from 0 (1st Optical link port in the 1st slot used). It is not known a priori which slot is used for first (it depends on the motherboard of the PC used).

Note: if an A2818 and an A31818 are installed at the same time, the A2818 always takes the link index 0, then the first link of the A3818 takes the link index 1 and so on (in case of multi-link A3818 version).

5.1.4 Conet Node

CONET is CAEN proprietary optical link protocol. In case of Daisy-chain connection, the *Conet Node* incremental index (default value is 0) identifies which device in the optical chain is being addressed. The node index is 0 for the first device in the chain, 1 for the second and so on.

5.1.5 PID N°

The *PID Number* is CAEN product identifier, an incremental number greater than 10000 that is unique for each product. The PID is on a label affixed to the product. The PID N° required by the software is the one of the A4818 adapter or V4718 Bridge, according to the connection type (find PID location in the Bridge and adapter documentation **[RD10][RD11]**).

5.1.6 IP Address

The IP address is the address of the V4718 Bridge over the ethernet link **[RD11]**.

5.1.7 Base Address (hex)

The Base Address (default value is 0) is meaningful only in case of VME digitizers (*Board Type* = *V1743*). This field must be filled in with the VME Base Address of the digitizer: a 8-digit hexadecimal number whose four MSB are given by the position of the relevant on-board rotary switches **[RD1]**, while the four LSB must be 0000.

5.1.8 Connect/Reboot

CONNECT: Once all the required connection parameters are set, this button starts the connection to the board. The "Connected" LED gives the user the status of the connection:

GREY = Disconnected BLINKING GREEN = Connection in progress GREEN = Connected

The connection process also initializes the board and normally requires a few seconds to be completed!

REBOOT: If connected, this button performs the reboot of the hardware.

5.2 Connection Examples

The parameters configuration for a set of typical connection cases is shown in **Tab. 5.3**.

HW connection chain	Conn. Type	Connection Parameters				
		Link N°	Conet Node	PID	IP Add.	Base Add.
PC → **USB** → DT5743	USB	0	-	-	-	-
PC → **USB** → V1718/V3718 → **VME** → V1743	USB	0	-	-	-	32100000(1)
PC → **USB** → DT5743(2)	USB	0/1	-	-	-	-
PC → **PCI/PICe** → A2818/A3818 → **CONET** → DT5743	OPTICAL	0	0	-	-	-
PC → **PCI/PCIe** → A2818/A3818 → **CONET** → V1743	OPTICAL	0	0	-	-	0
PC → **PCI/PCIe** → A2818/A3818 → **CONET** → V2718/V3718/V4718 → **VME** → V1743	OPTICAL	0	0	-	-	32100000(1)
PC → **PCI/PCIe** → A2818/A3818 → **CONET** → V1743(3)	OPTICAL	0	1	-	-	0
PC → **PCIe** → A3818 → **CONET** → V1743(4)	OPTICAL	1	0	-	-	0
PC → **USB** →A4818 → **CONET** → DT5743	USB_A4818	-	0	14122(5)	-	-
PC → **USB** →A4818 → **CONET** → V1743	USB_A4818	0	0	14122(5)	-	0
PC → ETH → V4718 → **VME** →V1743	ETH_V4718		-	-	192.168.0.254(6)	32100000(1)
PC → **USB** → A4818 → **CONET** → V2718/V3718/V4718 → **VME** → V1743	USB_A4818	-	0	14122(5)	-	32100000(1)

(1) *This VME Base Address is taken as an example; the real VME base address may vary and must be checked referring to the digitizer User Manual*

(2) *It is the case of two USB ports on the PC used to communicate with as many digitizers (see the examples at Chap. 9 of **[RD6]**)*

(3) *The Digitizer is intended to be the second board of an optical Daisy chain (see the examples at Chap. 9 of **[RD6]**)*

(4) *Link #1 of A3818 multi-link version is used to connect directly to the digitizer*

(5) *This PID number of the A4818 adapter is taken as an example*

(6) *It is the IP address of the V4718 bridge (default IP is takes as an example)*

Tab. 5.3: Examples of hardware connections and the relevant communication parameters

6 Main Frame

The WaveCatcher Main Frame shows up after the target digitizer is connected (**Fig. 6.1**).

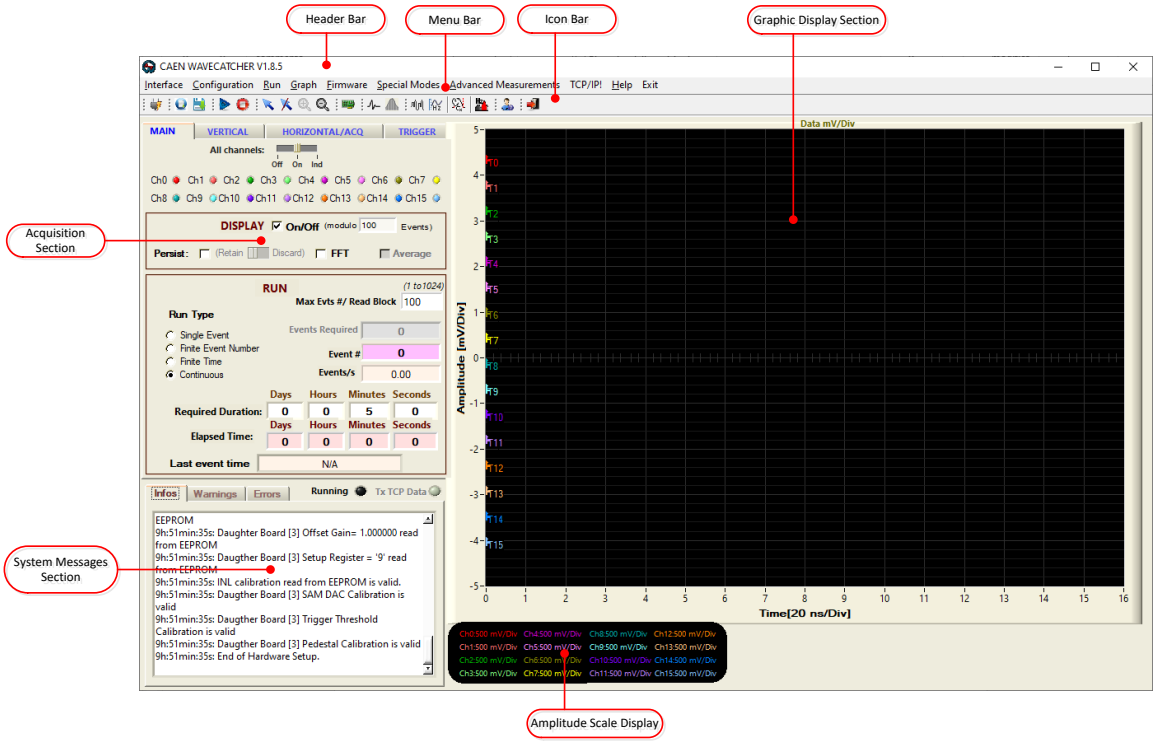


Fig. 6.1: Main Frame

It is possible to identify a set of sections in the Main Frame that will be described with increasing details in this document: The *Title* bar, the *Menu* bar, the *Icon* bar, the *Acquisition* section, the *System Messages* section, the *Graphic Display* section, the *Amplitude Scale* display.

6.1 Header Bar

This bar shows the software name, logo and version on the left, while the conventional Windows *Minimize, Zoom* and *Close* keys are available on the right.

6.2 Menu Bar

It is the first level of the software functions (Chap. **7**).

This bar includes the menu items below:

Interface/Configuration/Run/Graph/Firmware/Special Modes/Advanced/TCP-IP!/Help/Exit

6.3 Icon Bar

This bar collects a list of icons for a fast access to useful software functions (Chap. **8**):

Board Connect / Calibrate Pedestals / Save Pedestals to FLASH / Start (Run) / Stop (Run) / Enable Cursors/ Delete Cursors / Zoom In / Zoom Out / Firmware Version / Pulser Mode / Charge Mode / Noise Statistics / Rate Statistics / Time Measurements / Rate vs Threshold Measurements / *Software Users Guide / Exit*

6.4 Acquisition Section

It Includes 4 toggleable tabs to set all the required hardware and software parameters for the acquisition (Chap. **9**):

MAIN / VERTICAL / HORIZONTAL/ACQ / TRIGGER

Besides, two light indicators, *Running* and *Tx TCP-IP Data*, inform if an acquisition is running or a data transfer by TCP-IP protocol is taking place, respectively (the latter feature is not implemented yet).

6.5 Graphic Display Section

In this section, the digitized waveforms of the enabled channels can be displayed with different colour traces: up to 8 wave traces can be simultaneously plotted for Desktop and NIM modules, while up to 16 ones in case of VME modules. Cursors and zoom functions can also be used in this section.

6.6 Amplitude Scale Display

This active graphic section displays the amplitude scale (Y-axis) for each enabled/displayed channel by the same colour coding as for the relevant channel trace in the plot. The amplitude values refresh by applying changes of the scale in the VERTICAL tab (Chap. **9**).

6.7 System Messages Section

It is a runtime logging window made of 3 toggleable tabs (Chap. **10**): *Infos* / *Warnings* / *Errors*.

7 Menu Bar

The Menu bar, placed just under the Title bar (**Fig. 6.1**), permits to access to all the software functions.

Fig. 7.1: The Menu bar

A left click on the menu item opens the submenu; then, a left click on the submenu item enables the relevant function.

7.1 Interface Items

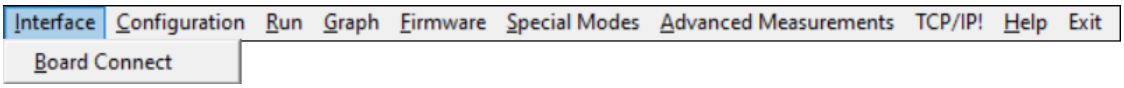


Fig. 7.2: Board Connect item

7.1.1 Board Connect

This item opens the Board Connection dialog box (Sec. **5.1**) to connect the target digitizer.

7.2 Configuration Items

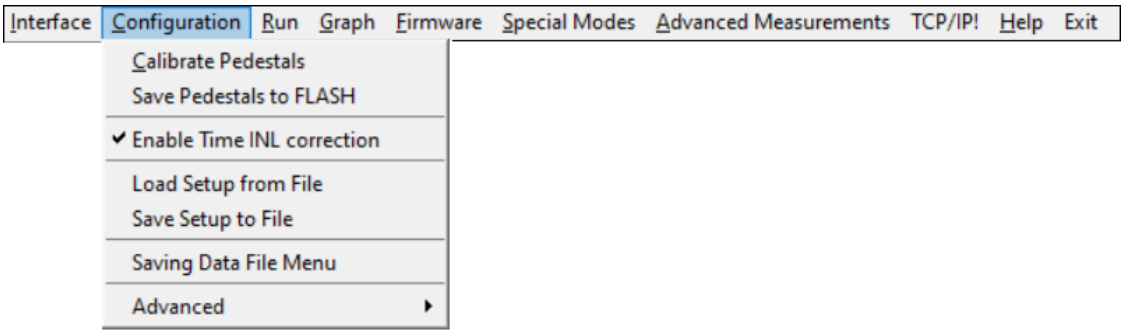


Fig. 7.3: Configuration items

7.2.1 Calibrate Pedestals

The x743 digitizer requires different types of data correction to compensate for unavoidable construction differences among the on-board SAMLONG chips **[RD1][RD2]**. This item opens a dialog box where the User is asked to enter the number of events upon which to perform the Pedestal Calibration; around 300 events are a typical entry for this calibration (**Fig. 7.4**). This is the only correction where the User can change the factory stored parameters.

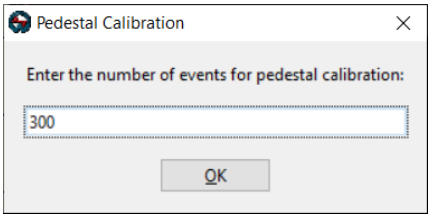


Fig. 7.4: Pedestal Calibration dialog box

The Pedestal Calibration procedure is recommended if high channel noise levels are observed in the *Noise Measurement* section (Sec. **7.7.1**). Typically, an acceptable noise value is considered around 0.79 mV RMS.

The procedure consists in the following steps:

- Make sure that no signal is provided on the digitizer analog input channels
- Set the channel DC Offset = 0, typically, in the Acquisition Section (Sec. **9.2.2)**
- Calibrate the pedestals by the *Calibrate Pedestals* function
- Save calculated parameters onto the digitizer by the *Save Pedestals to FLASH* function (Sec. **7.2.2**)

- Exit the WaveCatcher software and then launch it again to load the new correction parameters
- Check if channels noise level in the *Noise Measurement* section stays around 0.79 mV RMS.

7.2.2 Save Pedestals to FLASH

This item enables the function to save the pedestal values to the digitizer EEPROM. In the Pedestal Calibration procedure, it must be used after the pedestal calibration function (Sec. **7.2.1**).

7.2.3 Enable Time INL Correction

By this item, the user can enable the function of Integral Time Non-Linearity correction for the acquired data **[RD1][RD2]**.

7.2.4 Load Setup from File

Through this item, the User can import in WaveCatcher an acquisition configuration previously saved to a binary file (Sec. **11.1**)

7.2.5 Save Setup to File

This item allows the User saving to a binary file the current acquisition configuration (Sec. **11.1)**.

7.2.6 Saving Data File Menu

This item opens the File Menu dialog box where the User can manage the data saving. The output file can be configured to be ASCII or BINARY (*File type*) and the acquired data can be optionally split to multiple files by a selectable number of events per file.

Also, the User can configure here the attributes of the file name (a prefix or *BaseName*, *System Date*, *System Time* information, manual or auto-incremental *Run ID*). The destination directory for the saved files can optionally be the default one (*C:\Users\<USER>\AppData\Local\CAENWaveCatcher\RunData*) or user selectable at the start run (enabling the *Popup for Data Directory* option).

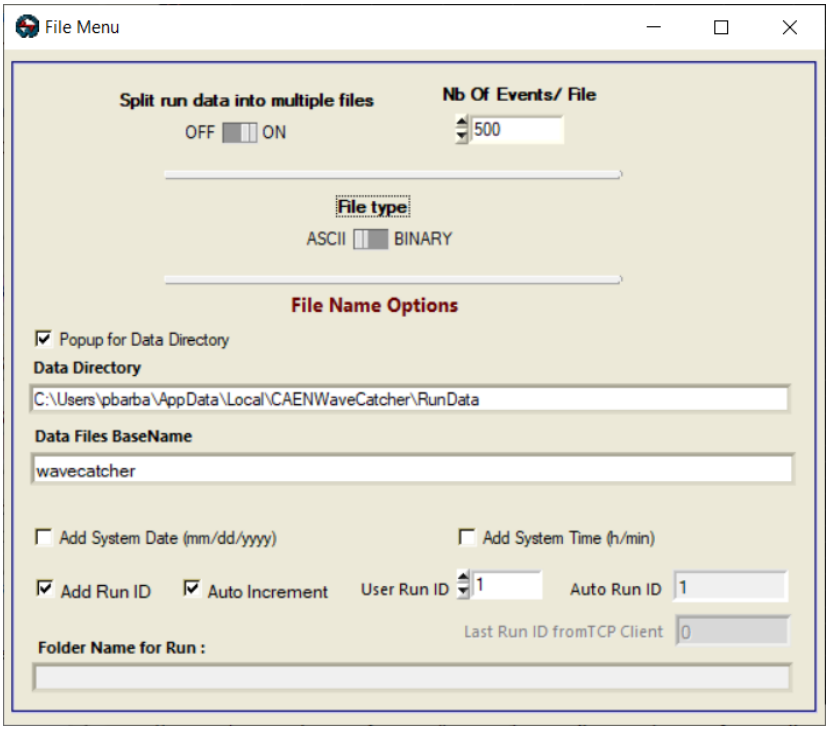


Fig. 7.5: File Menu dialog box

The *Saving Data File* item function applies only to waveforms or to waveforms and measurements data (Sec. **11.2**)

7.2.7 Advanced

The functions of this item are reserved exclusively for CAEN test purposes. Only the *Dump FLASH contents to Files* function is available for the User. It could be required in case of technical support an issue (Chap. **14**).

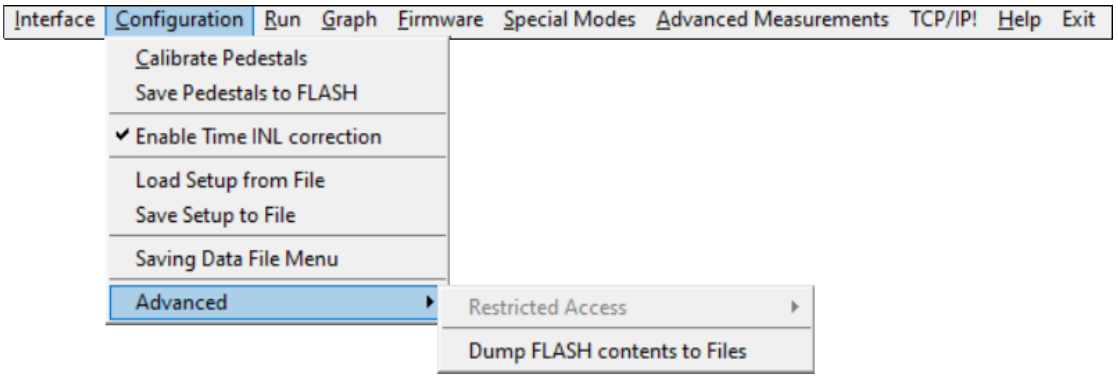


Fig. 7.6: Advanced items

7.3 Run Items

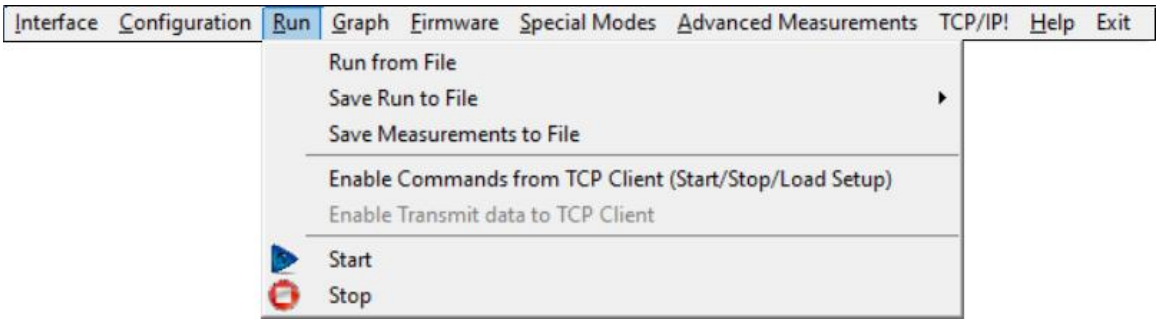


Fig. 7.7: Run items

7.3.1 Run from File

This Item enables the option to run from a data file previously saved. The file must have been saved with the same software version as the current one. The file directory and the file name are proposed at the start of the run. As long as this item is enabled, the software reads on event by event, after each stop and star, until the end of the file is reached. To read the file from the beginning, it is suggested to uncheck and check again the *Run from File* item.

7.3.2 Save Run to File

The function of this item is to select which data must be saved to file, between waveforms only and waveforms and measurements. Additional information and the format of the output files can be found in Sec. **7.2.6**.

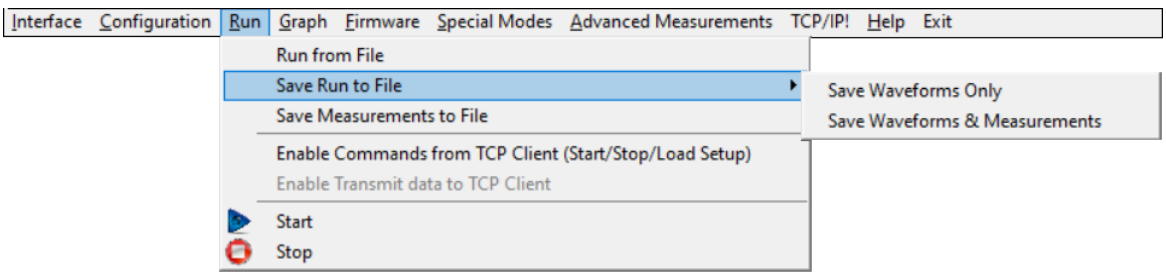


Fig. 7.8: Save Run to File item

- ***Save Waveforms Only***: by checking this option, the information saved to the output file is exclusively the portions of acquired waveforms made by as many samples of the digitized wave as configured by the recording depth parameter (see Sec. **9.3.3**).
- ***Save Waveforms & Measurements***: by checking this option, the saved file contains waveforms as well as charge and time measurements information; the huge amount of transferred data may affect the acquisition rate.

7.3.3 Save Measurements to File

The file saved through this item contains only charge and time measurements information (Chap. **11**).

7.3.4 Enable Commands from TCP Client (Start/Stop/Load Setup)

This item enables the software to receive defined commands from a TCP-IP client (Sec. **7.8**).

7.3.5 Enable Transmit Data to TCP Client

This item is for future development.

7.3.6 Start/Stop (Run)

These items control the start and stop acquisition. A software command is sent to the digitizer to simultaneously start and stop the acquisition on all channels.

7.4 Graph Items

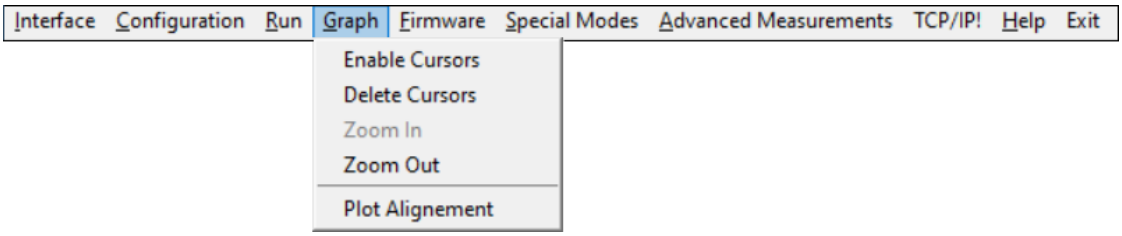


Fig. 7.9: Graph items

7.4.1 Enable/Delete Cursors

The function of these items is to toggle on and off the cursors in the Graphic Display section. Each cursor consists in two orthogonal yellow lines that can be moved within the graphic display area by their crossing point. The cursor can be activated buy left clicking with the pointer in the area within one division from its crossing point and can be dragged across the graph area. When active, the cursor is highlighted.

To set the cursor position, left click again once the desired position is reached; to release the cursor, place the pointer to a distance greater than one division and left click again: the cursor will return to the normal intensity.

The cursor values can be read in the Cursor Data Display which appears on bottom right of the Graphic Display section. Displayed values are the differences between cursors current positions along the X-axis (x1–x2) and the Y-axis (deltaY).

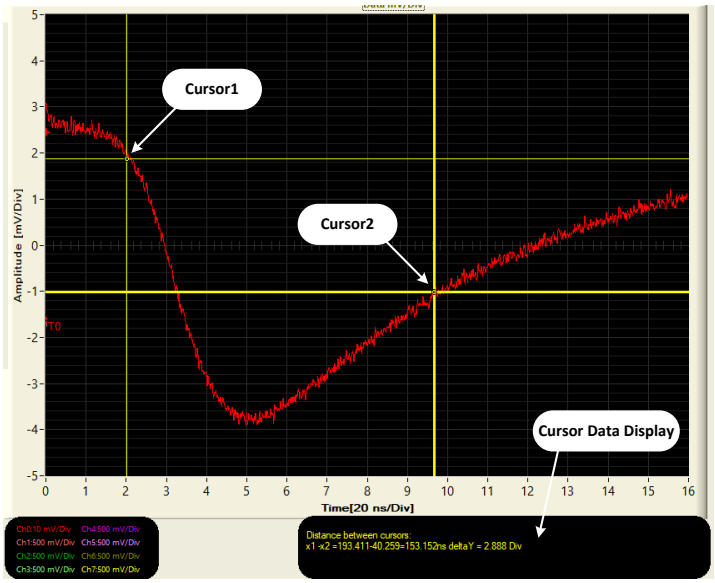


Fig. 7.10: Graphic cursors

7.4.2 Zoom In/Out

By left clicking on the *Zoom In* item, the user can expand in the waveform area on the graph display selected by the cursors. By left clicking on the *Zoom Out* item, the user can reduce the former expansion till the original dimensions of the waveform display are reached.

7.4.3 Plot Alignment (to be defined)

By left clicking on this item, a dialog box opens with the settings in **Fig. 7.11**.

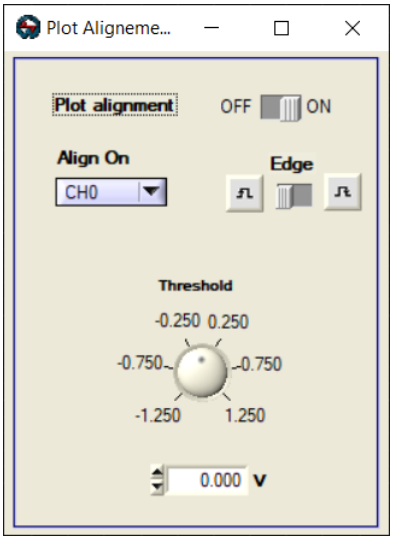


Fig. 7.11: Plot Alignment dialog box

7.5 Firmware Items

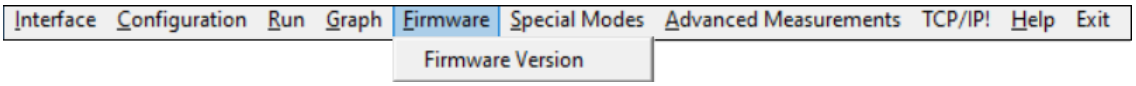


Fig. 7.12: Firmware items

7.5.1 Firmware Version

By left clicking on the *Firmware Version* item, the release number of the daughter-boards and the mother-board firmware is shown in the Info tab of the System Messages section (**Fig. 7.13**).

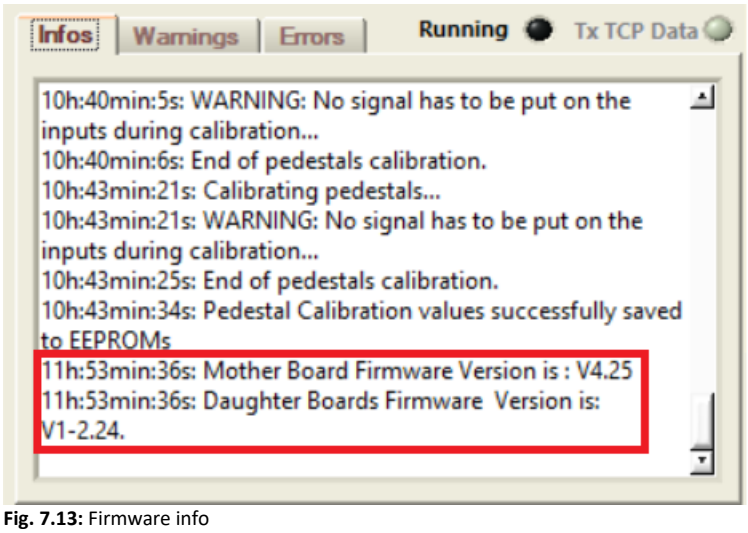


Fig. 7.13: Firmware info

7.6 Special Modes Items

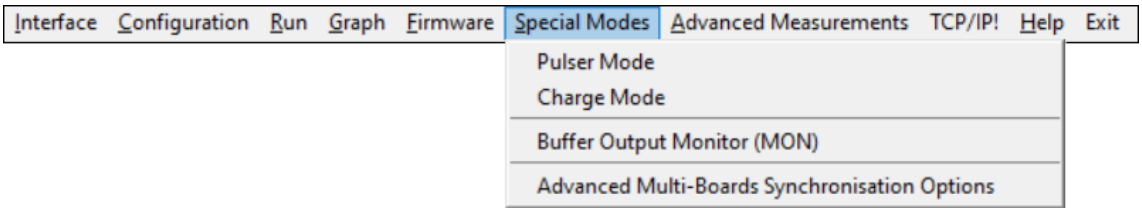


Fig. 7.14: Special Modes items

7.6.1 Pulser Mode

This item manages the Test Pattern Pulser which each channel of the digitizer is equipped with (see the digitizer User Manual).

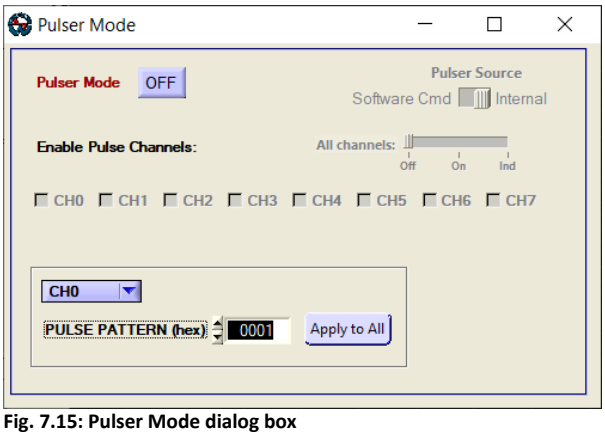


Fig. 7.15: Pulser Mode dialog box

By left clicking on the *Pulser Mode* item, a dialog box opens with the Test Pattern Pulser settings (**Fig. 7.15**):

- ***Pulser Mode*:** enables/disables the Test Pattern Pulser function; stop the acquisition before enable.
- ***Pulser Source*:** selects whether the test pulse pattern must be generated by Software Command or by the Internal Clock.
- ***Enable Pulse Channels*:** the test pattern pulse can be provided either to any channel, or to all channels at once, or individually on the enabled channels.
- ***Pulse Pattern*:** configures the test pulse pattern by a 4-digit hexadecimal entry (16 bits) for selectable channels or for all channels. Pulse traces can be managed like real waveforms by the settings in the Acquisition Section (Chap. **9**).

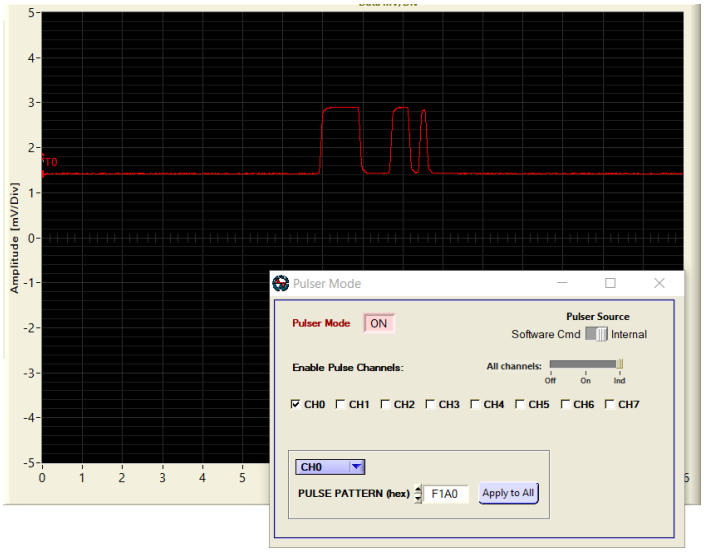


Fig. 7.16: Pulser Mode example

7.6.2 Charge Mode

This item manages the charge integration function. The digitizer firmware features an embedded Charge Mode option, where the FPGA can calculate the charge comprised within a predefined part of each event (see the digitizer User Manual).

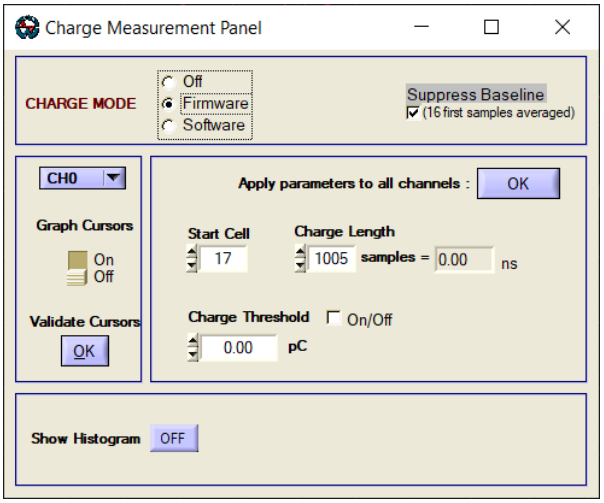


Fig. 7.17: Charge Measurement Panel

By left clicking on the *Charge Mode* item, the Charge Measurement Panel with opens with the following settings (**Fig. 7.17**):

- ***Charge Mode*:** optionally, disable the charge integration or enables a charge integration made at firmware (online in the firmware) or software level (online in the software). Stop the acquisition before enable.
- ***Suppress Baseline:*** if enabled, the baseline value for the charge integration is calculated upon the average of the first 16 samples of the acquired waveform.
- ***Graph Cursors***: if enabled, the interval of the event (wave) for the charge integration is defined through the cursors appearing in the plot, which need to be set and then validated to make the changes effective (*Validate Cursors*). It is possible to set different intervals for different channels (by the channel selector) or to apply the same interval to all channels (*Apply parameters to all channels*). Once validated, values are shown also in *Start Cell* and *Charge Length*.
- ***Start Cell/Charge Length***: the integration interval can also be directly set by entering the start cell sample and the cell length in samples (the interval is then shown converted in nanoseconds). Setting the *Charge Threshold* (in picocoulombs), charge values which are under the threshold will be provided, while those which are over the threshold will be cut off. It is possible to set different intervals for different channels (by the channel selector) or to apply the same interval to all channels (*Apply parameters to all channels*).

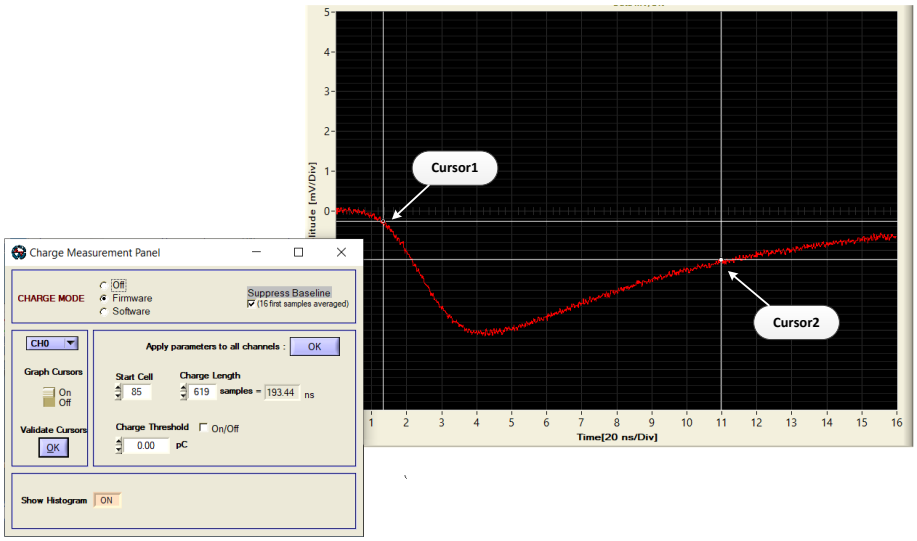


Fig. 7.18: Charge Integration interval selection

- ***Show Histogram*:** opens the Charge Histogram dialog box (**Fig. 7.19**) where it is possible to select the channel to plot, possibly configuring the charge region of interest to be plotted (*Measured Range*); an auto Y-axis scaling or

a user configurable fixed range may be selected (*Y Axis Range*); the user can also configure the number of bins for the histogram plot (*Nb of bins*), save the histograms to file (*Save Histos*)or reset the histograms plot (*Reset Histos*). The format of the output histogram file is described in Chap. **11**.

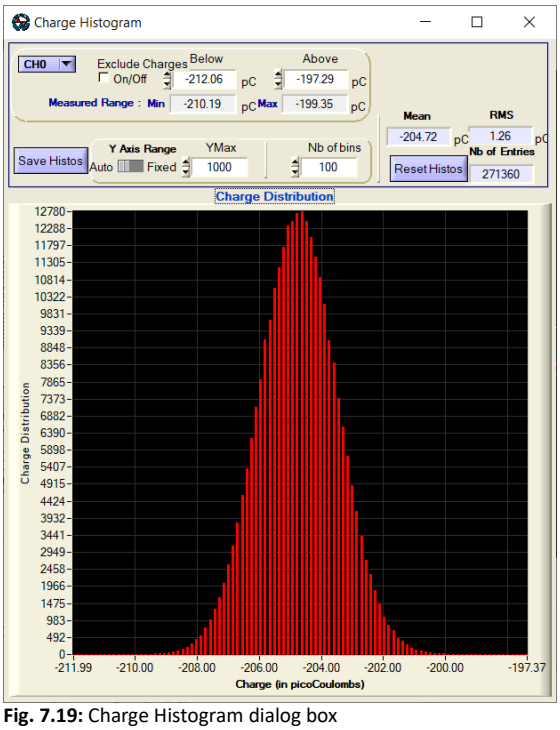


Fig. 7.19: Charge Histogram dialog box

7.6.3 Buffer Monitor Output (MON)

This item programs the Buffer Occupancy function on the 12bit 100MHz $1V_{pp}$ DAC output (LEMO connector) of the V1743 digitizer. The DT5743 is not provided with such output connector.

The DC voltage level provided on MON output increase by a fixed step of 0.976 mV each time that a buffer of the digital memory is filled with events. The number of buffers in which the channel digital memory is divided depends on the programmable event size (Sec. **9.3.3**).

In the Buffer Monitor dialog box (**Fig. 7.20**), it is possible to set the gain to magnify the fixed step, specifically useful in case of a memory divided in few buffers. The gain values are programmable in powers of two with the exponent ranging between 0 (default gain = 1) and 10 (maximum gain = 1024).

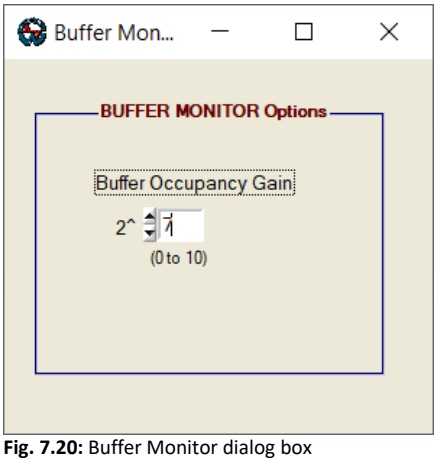


Fig. 7.20: Buffer Monitor dialog box

7.6.4 Advanced Multi-Boards Synchronization Options (VME only)

This item, available only for the V1743 version, allows configuring the digitizer in the case of the multi-board synchronized system schematized in **Fig. 5.1**.

Before running WaveCatcher, the cable connections of the hardware setup and the synchronization of the clocks must have been performed the way they are described in the Multi-Board Synchronization chapter of CAEN reference document **[RD3]**.

Then:

- On the host PC, make as many copies of the WaveCatcher folder as the boards in the system.
- Open multiple instances of WaveCatcher software: one for the master board (first board in the chain) and the others for each slave in the system.
- In the Advanced Multi-Boards Synchronization Options panel, configure the master and the slaves.
- Configure the run settings on the master board (Sec. **9.1.3**); they will drive all the other boards.
- Configure and enable the wanted saving option on all the boards (Sec. **7.2.6** and Sec. **7.3.2**).
- First, give the start Run to all the slave boards to arm them for the acquisition; then, give the start Run to the master and the acquisition will start on all the boards at once.
- Give the Stop run to the master board to stop all the system (in case of finite run type setting, the master automatically stops once the stop condition is reached).

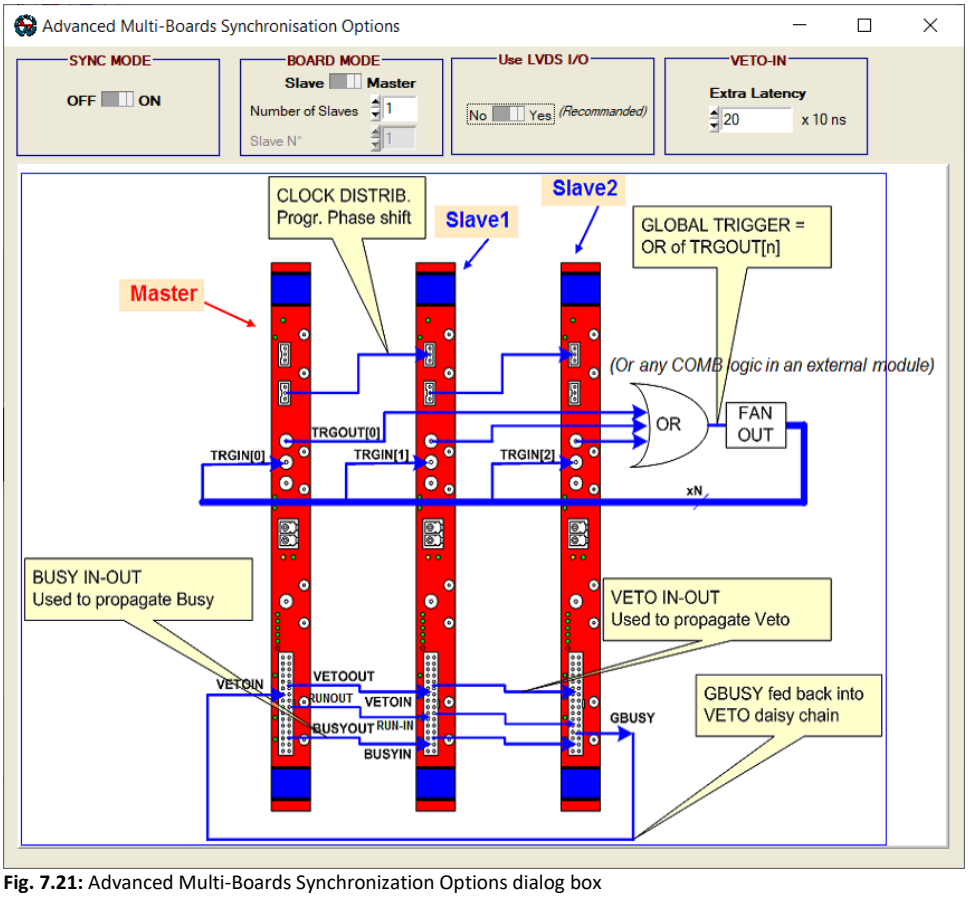


Fig. 7.21: Advanced Multi-Boards Synchronization Options dialog box

- ***SYNC MODE*:** Must be ON to enable the synchronization mode.
- ***BOARD MODE*:** By setting the *Master* option, the board is configured as master in the clock chain; selecting the *Slave* option, the board is configured as clock slave. In the slave option, it is then necessary to specify the number of slaves in the multi-board system (*Number of Slaves*) and the position occupied by the slave in the clock chain (*Slave N°*).
- ***Use LVDS I/O*:** Enables the Run/Busy/Veto management through the LVDS I/O connector to propagate the run signal and guarantee the data alignment between digitizers (especially when working at high rates). The LVDS I/O are configured as described in the reference document **[RD3]**.

- ***VETO-IN*:** Extends the veto duration; the veto signal on the LVDS is generated with a configurable delay in steps of 10 ns (200 ns by default).

USERS WHO NEED A DIFFERENT MULTI-BOARD CONFIGURATION CAN CONTACT CAEN FOR SUPPORT (CHAP. 14)

7.7 Advanced Measurements Items

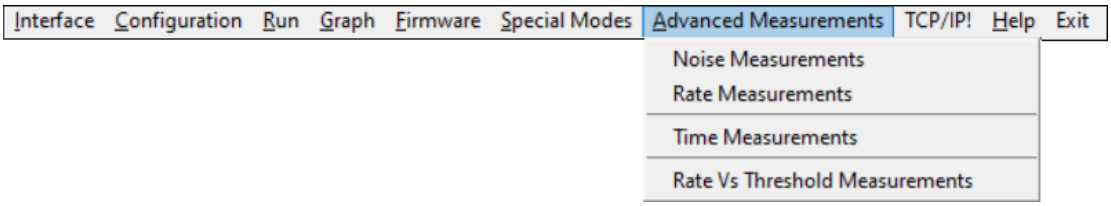


Fig. 7.22: Advanced Measurements items

7.7.1 Noise Measurements

This item manages the Noise Measurements function.

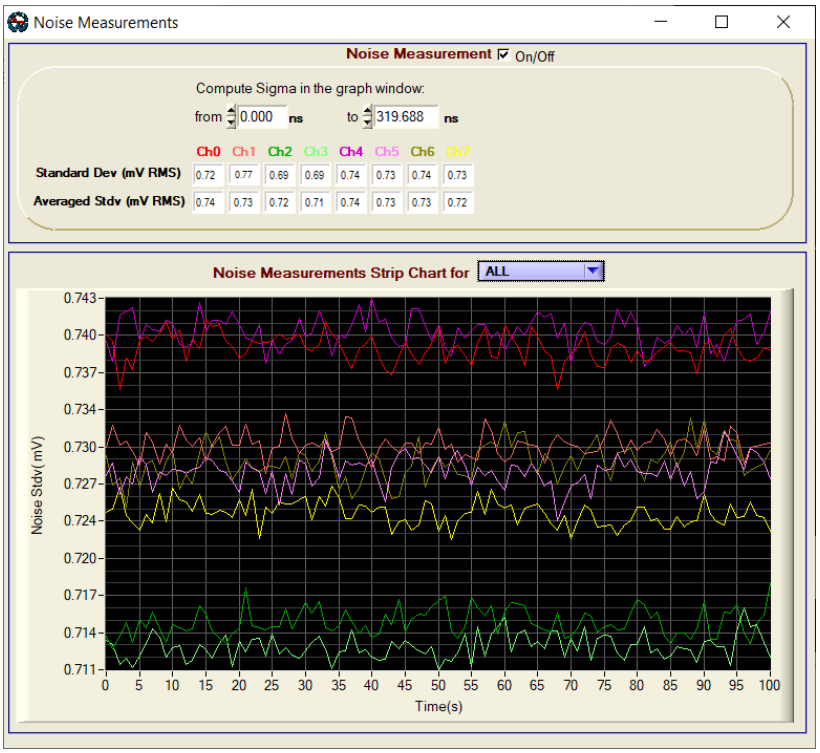


Fig. 7.23: Noise Measurements dialog box

By left clicking on the *Noise Statistics* item, the Noise Measurements dialog box opens with the following settings (**Fig. 7.23**):

- ***Noise Measurement*:** Enables/disables the noise measurements; acquisition must be stopped before enable.
- ***Compute Sigma in the graph window*:** Selectable plot range in which the Sigma value of the noise is computed.
- ***Standard Dev (mV RMS)*:** Shows the runtime value of the standard deviation computed on the input wave samples within the selected range.
- ***Averaged Stdv (mV RMS)*:** Shows the runtime value of the averaged standard deviation from the beginning of the run.
- ***Noise Measurement Strip Chart*:** It is the strip chart plot of the Noise Standard Deviation values in RMS versus Time in seconds.

The *Noise Measurements* function can be used in combination with the *Pedestals Calibration* function (Sec. **7.2.1**).

7.7.2 Rate Measurements

This item manages the Rate Measurements function. The real raw trigger rate is measured for each channel independently of the acquisition rate, thanks to the individual discriminators which the digitizer is equipped with (see the digitizer User Manual).

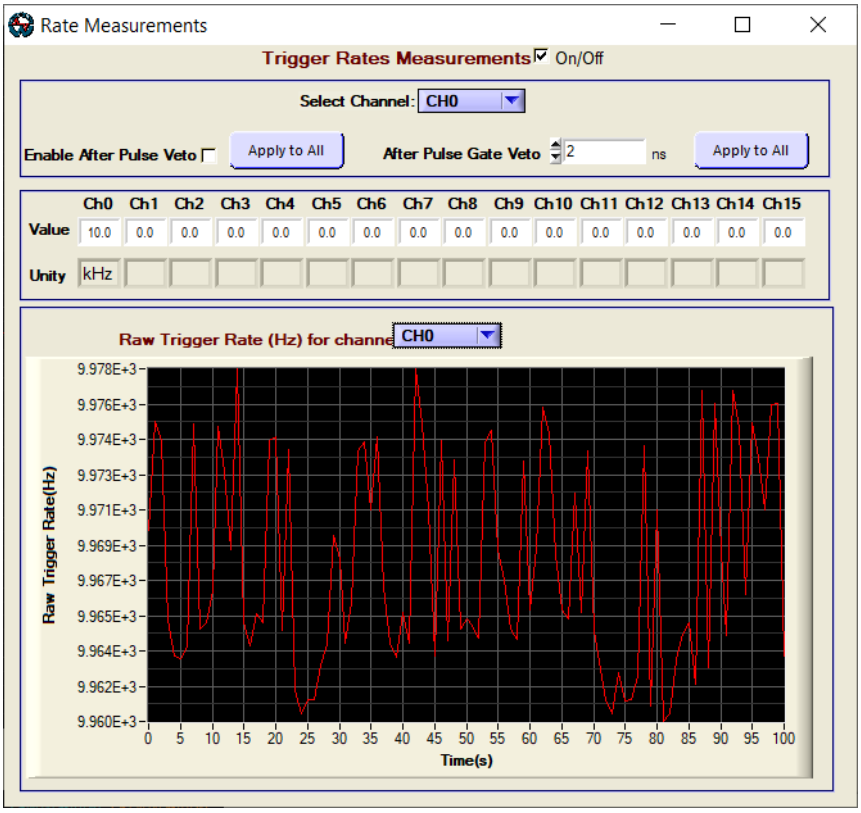


Fig. 7.24: Rate Measurements dialog box

By left clicking on the *Rate Statistics* item, the Rate Measurements dialog box opens (**Fig. 7.24**) with the following settings:

- ***Trigger Rates Measurements*:** Enables/disables the rate measurements; acquisition must be stopped before enable.
- ***Enable After Pulse Veto*:** If selected**,** enables the inhibit of the trigger counting within an adjustable time window after the digitization starts.
- ***After Pulse Gate Value*:** Sets the value of the time window for the trigger counting inhibit in ns.
- ***Value*:** For each channel, the current measured rate value is displayed.
- ***Unit*:** It is the unit of measure in which *Value* is expressed (dynamically Hz, kHz or MHz).
- ***Raw Trigger Rate (Hz) for channel*:** For a selectable channel, it is the strip chart plot of the Raw Trigger Rate in Hertz versus Time in seconds.

7.7.3 Time Measurements

This item manages the Time Measurements function to be applied to waveforms with single pulses. Options like the measured Leading/trailing Times put in the data files, time distance histograms as well as some parameters for the computation of the Amplitude or the Baseline are available. In case of multiple pulses or overlapping pulses, the results can be irrelevant.

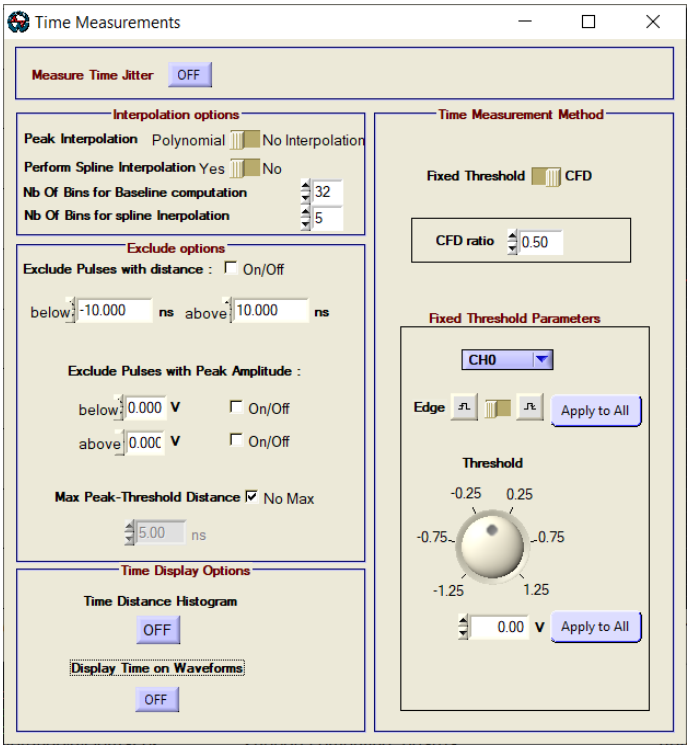


Fig. 7.25: Time Measurements dialog box

By left clicking on the *Time Measurements* item, the Time Measurements dialog box opens with the following settings (**Fig. 7.25**):

- ***Measure Time Jitter***: Enables/disables the time measurements; acquisition must be stopped before enable. Enabling *Measure Time Jitter* lets the Time Distance histogram be built in.
- ***Interpolation options***:
  - *Peak Interpolation*: If no interpolation is selected, the peak is equal to the maximum value of the samples (positive or negative); if the interpolation is selected, the 3 points (i.e. samples) before and the 3 points after the maximum value (i.e. sample of maximum value) are used in a polynomial interpolation to define the peak value.
  - *Perform Spline interpolation*: Cubic spline can be used to interpolate between samples.
  - *Nb of Bins for Baseline computation*: It is the number of samples at the beginning of the waveform that will be averaged and considered as a baseline. This number of bins is also used for the baseline and charge measurement s that are added to data files.
  - *Nb of Bins for spline Interpolation*: It is the number of bins between samples that is added by the cubic spline interpolation.
- ***Time Measurement Method***: Two optional methods available for the pulse leading and trailing times calculation.
  - *CFD (Constant Fraction Discriminator)*: With pulses of varying amplitude, this method offers a lower jitter; the user enters the *CFD ratio* according to the signal shape; to minimize the jitter, this ratio should be at the maximum of the slope of the signal. The software calculates the baseline (see *Interpolation options*), then the polarity of the pulse is automatically detected (it looks for the peak, with or without interpolation, and if the value is negative then the pulse is negative, otherwise it is a positive pulse). The amplitude is computed by subtracting the peak to the baseline value. The threshold is then given multiplying the CFD fraction (between 0 and 1; 0.5 by default) by the amplitude. Finally, the algorithm looks for the two samples around the threshold and makes linear interpolation for the time.
  - *Fixed Threshold*: With signals of a fixed amplitude or signals with a “plateau” and an unclear peak, this method can be more efficient; the user defines a fixed *Threshold* selectable for each channel and defines

the *Edge* (rising or falling) for the leading time computation; the other edge will be used to compute the trailing time.

- ***Time Display Options:***
  - *Time Distance Histogram*: The software permits to display the histogram of the time distance between each pair of channels that were enabled during the run (Sec. **9.1.1**). The Mean, RMS and *FWHM* (Full Width Half Maximum) values of the distribution are monitored in real time during the acquisition each N events, where N is the % event selected by the User in the Main tab (Sec. **9.1**). Referring to the Time Difference Distribution plot, the User can select between the automatic and manual option for the x-axis scale. On the stop acquisition, a Gaussian fit is applied to the distribution (cyan trace) and the fitted Mean, Sigma, and FWHM are displayed (*After gaussian fit*). Histograms can be saved to file through the *Save Histo* key (Chap**. 11**). By the Show Mean Distance vs Time Strip Chart button, the homonym plot opens (Fig. 7.26: **Time Measurement Histogram dialog boxFig. 7.26**).
  - *Display time on Waveforms*: It permits to display on the waveform the position of the computed leading time. This option can be enabled even if the time measurements are disabled (*Measure Time Jitter*).

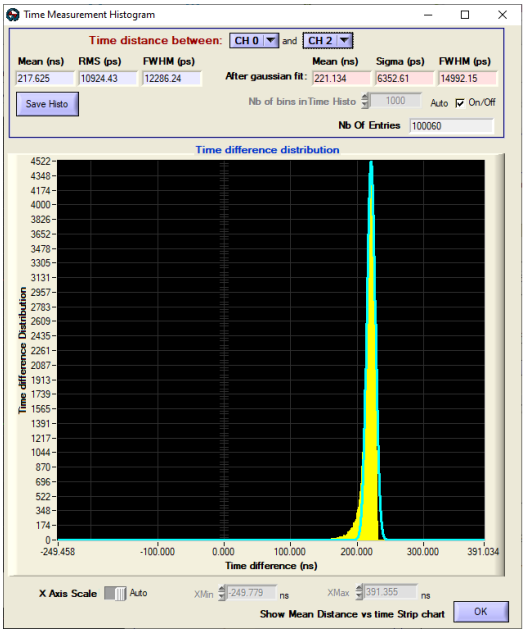


Fig. 7.26: Time Measurement Histogram dialog box

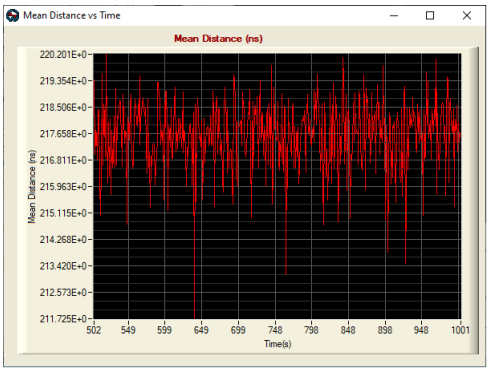


Fig. 7.27: Mean Distance vs Time plot

- ***Exclude Options*:** These options can be applied to the Time Distance Histogram (*Time difference distribution*). It is possible to exclude time distances above and below selectable values. It is also possible to exclude pulses with amplitude above and below selectable values. It is even possible to exclude pulses with a distance between the peak and the leading time above a certain value (this can be useful to exclude waveforms with multiple pulses or overlapping pulses, for example).

7.7.4 Rate vs Threshold Measurements

Through this item, it is possible to perform Hit Rate versus Threshold measurements, basing on the on-board individual hit rate monitor logic **[RD1][RD2]**.

By left clicking on the *Hit Rate vs Threshold Measurements* item, the Hit Rate Vs Threshold Plot dialog box opens with the following settings (**Fig. 7.28**):

- ***Threshold Settings*:** The user can configure the threshold range (*Min. Threshold* and *Max. Threshold*) in which the hit rate measurements will be taken.
- ***Nb of steps*:** It is the selectable number of hit rate calculations to be performed in the defined range.
- ***Waiting time/step***: It is the selectable time interval between two consecutive hit rate calculations.
- ***Start Run/Force Stop*:** These keys start/stop the Hit Rate vs Threshold measurement, populating the plot with data (*Hit Rate vs Threshold*); the channel DC Offset is forced to 0 during the process.
- ***Hit Rate vs Threshold plot*:** The software permits to display the plot of the Hit Rate (in Hertz) vs Threshold (in Volts) measurements, for a selected channel, in a linear or logarithmic scale (*Log Scale*).
- ***Save result to File*:** It is possible to save the measurement data to an output file (Chap. **11**).

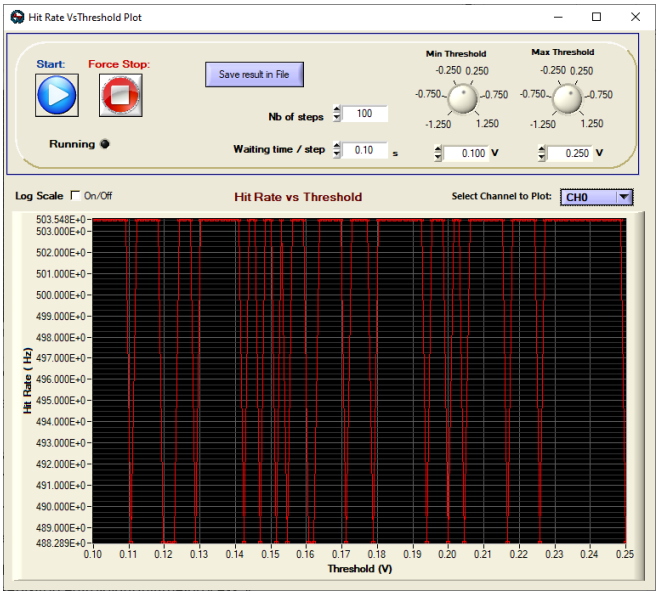


Fig. 7.28: Hit Rate Vs Threshold Plot dialog box

7.8 TCP-IP! Item

If enabled (Sec. **7.3.4**), this function allows the User sending a set of commands from a TCP/IP client to the TCP/IP server, where WaveCatcher is supposed to be installed, performing a basic remote control.

Fig. 7.29: TCP-IP! Item

The defined commands are:

- **LOAD_SETUP_FROM_FILE:<PATH>**, that imports a configuration setup:

  Example: *C:\\Users\myusername\\my_folder\\my_setup_folder\\setup_file.dat*

- **RUN_START<RunID>**, that starts the acquisition:

  Example: *RUN_START00000001*

- **STOP**, that stops the acquisition.

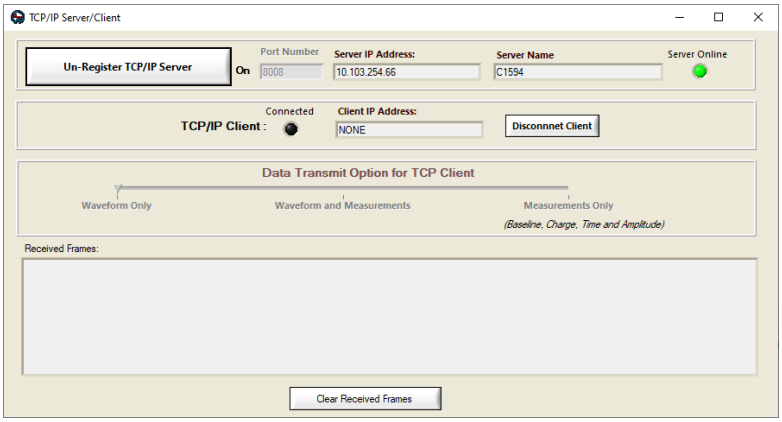


Fig. 7.30: TCP-IP dialog box

The possibility to transmit data for TCP-IP client is a future development.

7.9 Help Items

7.9.1 Software User's Guide

Through this item, it is possible to access the software documentation.

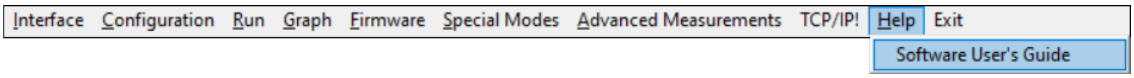


Fig. 7.31: Help Items

A left click on the *Software User's Guide* item opens the PDF version of the WaveCatcher User Manual.

7.10 Exit Items

7.10.1 Exit

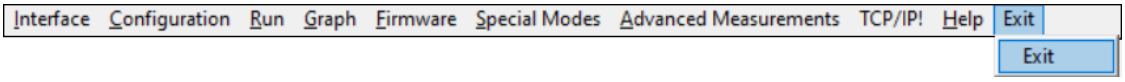


Fig. 7.32: Exit Items

A left click on the *Exit* item permits to quit the WaveCatcher software.

8 Icon Bar

The Icon bar is positioned just under the Menu bar (**Fig. 6.1**) and permits to quickly access the main functions of the Menu bar by a click on the related symbol.

Fig. 8.1: Icon Bar

The correspondence between the icons in the bar (**Fig. 8.1**) and their function is described in the table below (**Tab. 8.1**).

Function	Name	Icon
Opens the Board Connection dialog box (Sec. **5.1**)	Board Connect	
Imports a configuration setup (Sec. **11.1.1**)	Load Setup from File	
Exports a configuration setup (Sec. **11.1.2**)	Save Setup to File	
Starts the acquisition (Sec. **7.3.6**)	Start Acquisition	
Stops the acquistion (Sec. **7.3.6**)	Stop Acquistion	
Enables the plot cursors in the Graph Display (Sec. **7.4.1**)	Enable Cursors	
Disables the plot cursors in the Graph Display (Sec. **7.4.1**)	Delete Cursors	
Enables the Zoom In in the Graph Display (Sec. **9.1.2**)	Zoom In	
Enables the Zoom Out in the Graph Display (Sec. **9.1.2**)	Zoom Out	
Reads the target digitizer firmware revisions (Sec. **7.5.1**)	Firmware Versions	
Opens the Pulser Mode dialog box (Sec. **7.6.1**)	Pulser Mode	
Opens the Charge Measurement Panel (Sec. **7.6.2**)	Charge Mode	
Opens the Noise Measurement dialog box (Sec. **7.7.1**)	Noise Measurements	
Opens the Rate Measurements dialog box (Sec. **7.7.2**)	Rate Measurements	
Opens the Time Measurements dialog box (Sec. **7.7.3**)	Time Measurements	
Opens the Rate vs Threshold Measurements dialog box (Sec. **7.7.4**)	Rate vs Threshold Measurements	
Opens the Software User Manual (Sec. **7.9.1**)	Software User's Guide	
Quits the software (Sec. **7.10.1**)	Exit	

Tab. 8.1: Icon Bar table

9 Acquisition Section

9.1 MAIN Tab

The Main tab includes input channels enable settings, Graph Display section settings, readout, and acquisition settings.

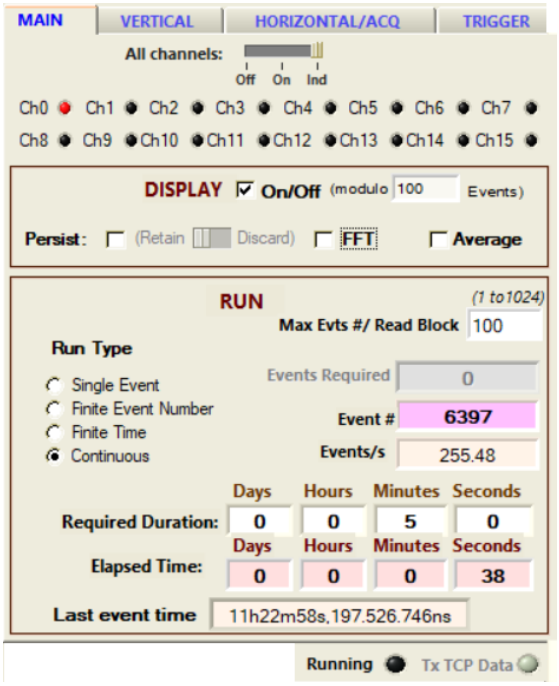


Fig. 9.1: Main tab

9.1.1 Channel Settings

The digitizer input channels can be enabled and disabled all at once (*Off*, *On*) or independently (*Ind*).

Moving the *All channels* slide selector on *Ind*, each channel can be enabled/disabled just by a click in the relevant check-cell. When enabled, a color code is automatically associated to the channel that will match the waveform trace colour.

9.1.2 Graph Display Settings

In this section, the user can set functions to be applied to the Graph Display section.

- ***DISPLAY***: If checked (*On*), data are continuously updated in the plot; if uncheckd (*Off*), data in the plot are updated at a lower frequency, that is every mod(N) events, where N is selectable by the User.
- ***Persist***: Sets the Persistence mode similar to a conventional oscilloscope; starting from the first waveform, all new coming ones are overwritten to it in the plot: no waveform is erased and the successive traces overlap.
- ***Retain/Discard***: This setting is valid only if *Persist* is checked; Retain Mode (*Retain*) makes possible zooming on the plot, but Graph data are continuously saved to memory: to avoid memory space saturation, it is recommended to run in Finite Time or Finite Event Number Mode (Sec. **9.1.3**).
- ***FFT***: Applies and displays the Fast Fourier Transform of the acquired waveform. The frequency components of the signal are on the X-axis (MHz), while the amplitude values of the corresponding frequencies are on the Y–axis (dB).
- ***Average***: Displays the waveform resulting from the accumulated average of the incoming waveforms.

9.1.3 RUN Settings

- ***Run Type*:** Sets the run mode.

  Options are:

  - *Single Events*: Single Mode arms the digitizer; when a valid trigger arrives, the board acquires an event on all channels and acquisition is stopped.
  - *Finite Event Number*: Finite Mode arms the digitizer and permits an event-driven run; after the number of valid triggers set by the User is received (*Events Required*), the acquisition is stopped; the current number of valid events recorded is monitored runtime (*Event #*).
  - *Finite Time*: Finite Time Mode arms the digitizer and permits a time-driven run; after the time interval configured by the User (*Required Duration*), the acquisition is stopped; the elapsed time is shown runtime (*Elapsed Time*).
  - *Continuous*: Continuous Mode makes the digitizer acquire data continuously until a Stop Acquisition command is manually issued by the User; the current number of valid events recorded is shown (*Event #*).

- ***Last event time*:** Shows the timestamp value of the last recorded event.
- ***Events/s*:** Shows the rate of valid events/second (updated every 1 s).
- ***Max Num Evts/ Read Block*:** Configures the maximum number of events that can be read from the board in one block transfer before to be processed by the software. This parameter can range from 1 up to 1024 (default is 100). Higher values optimize the data bandwidth increasing the supported maximum input rate. Anyway, this parameter needs to be tuned by the user: normally, it has a plateau beyond which it does not make any further beneficial contribution; in fact, it requires bigger CPU work, depending on the software data processing (measuring time, charge histogramming etc.), which may lead the board to work in burst-like mode.
- ***Running*:** This green LED lights on while the acquisition is running.
- ***Tx TCP Data:*** Future development.

Note: The software updates automatically the "modulo events" with respect to the *Max Num Evts/ Read Block* permitting to run faster when the display in off.

9.2 VERTICAL Tab

This tab includes the analog and digital channel offset settings and the configuration of the Graph Display vertical scale.

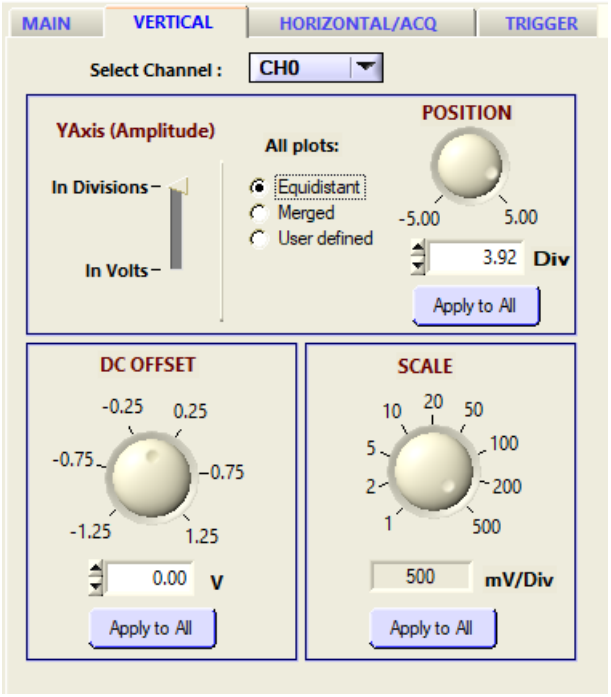


Fig. 9.2: Vertical tab

9.2.1 Y-Axis and Digital Offset Settings

- ***YAxis (Amplitude)*:** Sets the unit of the Y Axis values either in Volts (all the plots are then merged and the only way to scale the graph is to use the Zoom In/Out) or in Divisions (the user can then choose different scales on each channel) by toggling a control slider. The traces spacing can be selected (for all displayed traces) through the *All plots* settings.
- ***All plots*:**
  - *Equidistant*: Each trace is positioned at the same distance from the previous and from the following trace.
  - *Merged*: All traces have the same digital offset.
  - *User defined*: The user can position each trace independently on the Graph Display area, by selecting different digital offsets. The channel can be selected by the *Select Channel* setting and the digital offset applied through the *POSITION* setting.
- ***POSITION*:** This is not a hardware setting, but a digital offset applied by the software that permits moving the trace vertically in the Graph Display area, ranging between -5 and +5 divisions. Coarse setting is possible through the knob, while a fine setting (position resolution of 0.01 division) is available through the *Up* and *Down* arrows. The same digital offset can be applied to all the channels at once by the *Apply to All* key.

9.2.2 DC OFFSET Settings

- ***DC Offset*:** This is a hardware setting; it sets the analog offset applied to the selected channel input of the digitizer (range: -1.25 to +1.25 V) within the ADC dynamic, according to the input signal polarity, avoiding saturations. Each channel can have a different offset applied by the *Select Channel* setting and then setting the desired value by the knob (coarse setting) or through the *Up* and *Down* arrows with a voltage resolution of 0.01 V (fine setting). The same DC offset value can be applied to all the channels at once by the *Apply to All* key.

Note: Changing the DC offset value, the software automatically changes the trigger threshold ranges accordingly in the Trigger Tab (Sec. **9.4**).

9.2.3 Vertical Scale Settings

- ***SCALE*:** This is a purely digital zoom which changes the Graph Display vertical scale in the range between 1 mV/Div and 500 mV/Div configurable by the knob. The same scale can be applied to all the channels at once by the *Apply to All* key. Setting the scale value refreshes the Amplitude Scale Display.

9.3 HORIZONTAL/ACQ Tab

The settings in this tab are common to all channels of the target digitizer.

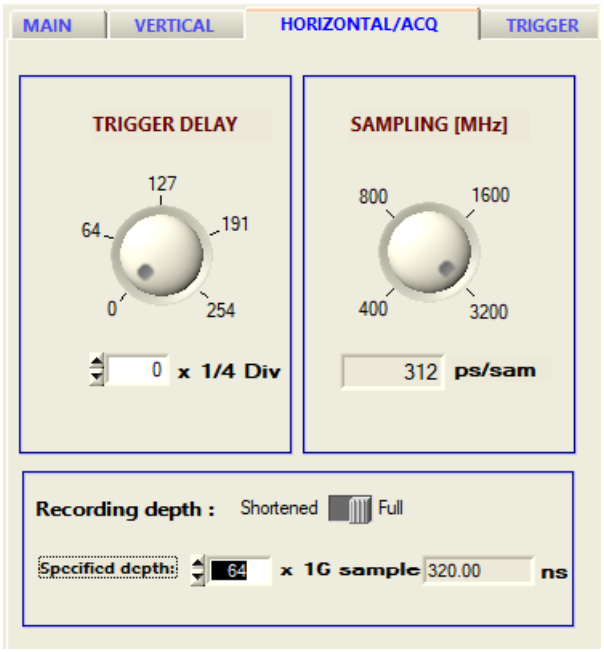


Fig. 9.3: Horizontal/Acq tab

9.3.1 Post-Trigger Settings

- ***TRIGGER DELAY*:** It is the post-trigger setting (hardware setting), that is the time during which, after the trigger condition occurs, the signal is still recorded before the memory content is frozen and then displayed. The post-trigger is set by the knob or by the *Up* and *Down* arrows; the value is expressed in ¼ of the X-Axis division units (i.e. 16 *SAMLOGN sampling period) and ranges between 0 and (254 * ¼) divisions.

  As an example, *TRIGGER DELAY* = 1 means a 5 ns of delay at 3.2 GS/s.

  If *TRIGGER DELAY* = 0, the position of a pulse corresponding to the trigger decision is between division 12 and 13. The trigger delay value.

9.3.2 Sampling Frequency Settings

- ***Sampling [MHz]*:** Permits configuring the digitizer sampling frequency (hardware setting) selecting among within four supported values: 400 MS/s, 800 MS/s, 1600 MS/s and 3200 MS/s (i.e. 2.5 ns/S, 1.25 ns/S, 625 ps/S and 312 ps/S); the sampling frequency value can be set through the knob.

9.3.3 Recording Depth Settings

These are hardware settings which define the portion of the input waveform that must be stored in the channel memory (also referred to as recording depth); the channel memory is internally organized in 16-sample segments. The minimum recording depth of the digitizer channel memory is 4 * 16 samples; the minimum record time is then equivalent to 20 ns record length when the sampling rate is 3.2 GS/sec. The maximum recording depth of the channel memory is 64 * 16 samples, that is 2.5 µs of record time when the sampling rate is 400 MS/s.

- ***Recording depth*:** Sets a *Full* or *Shortened* recording depth; *Full* corresponds to 64 * 16 samples, while *Shortened* ranges from 4 to 63 adjacent segments of 16 samples each.
- ***Specified Depth*:** Sets the number of 16 samples segments to be recorded; if *Specified depth* < 64 (segments), then *Recording depth* is automatically set to *Shortened*. The full recording depth scan be restored by setting *Recording depth* to *Full*.

9.4 TRIGGER Tab

All the settings of this section concern the trigger mode and logic configuration.

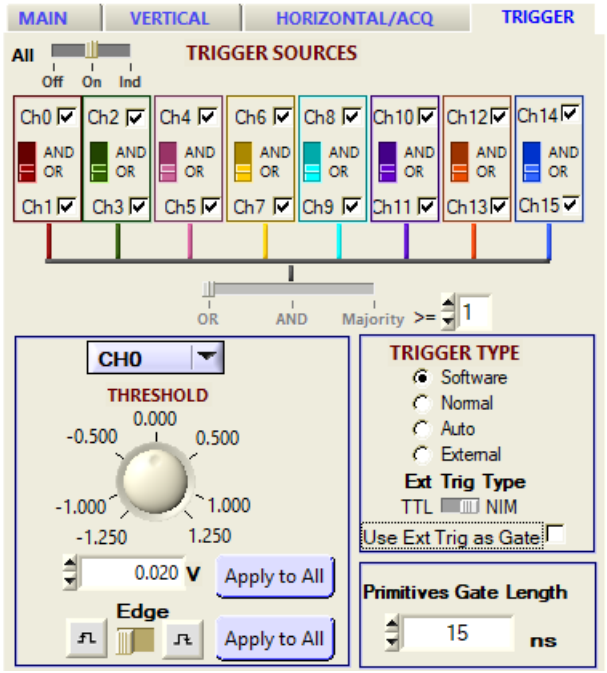


Fig. 9.4: Trigger tab

9.4.1 Trigger Source Settings

Note: These settings are effective only in case of *TRIGGER TYPE* = *Normal*.

- ***TRIGGER SOURCES*:** This setting defines the triggering conditions of the input channels of the digitizer; specifically, it is possible to enable/disable the self-triggers of the channel to participate in the global trigger (acquisition trigger) generation and to configure the Channel Trigger Logic for each pair of adjacent channels (see the digitizer User Manual).

  self-triggers of the channels can be enabled and disabled all at once (*On*/*Off*) or enabled/disabled individually (*Ind*) by just clicking the channel checkbox.

  For a channel pair, the logic combination of the self-triggers ca be selected by toggling the relevant slider (*AND*/*OR*).

  The outputs of the Channel Trigger Logic can further be logically combined at the mother-board level of the digitizer; in the software, this is set by the slider under the checkboxes: *OR*/*AND*/*Majority*. The majority level can be configured by the *Up* and *Down* arrows: it is the minimum number of valid pair outputs that will generate a valid trigger for the event acquisition.

- ***Primitives Gate Length*:** It is the length of the primitives (pulses) built when the channel signal crosses the discriminator. These pulses of programmable length participate in the Channel Trigger logic (AND, OR between groups of 2 channels set in *TRIGGER SOURCES*) and the result is sent to the mother-board to be processed in OR, AND or Majority. The parameter ranges between 15 ns + 255 * 5 ns (i.e. 1275 ns). When implementing coincidences between channels, *Primitives Gate Length* defines the coincidence time window.

9.4.2 Trigger Mode Settings

- ***Trigger Type*:** Selects the Trigger Mode.
  - *Software*: A trigger command is generated periodically by the software; when the software trigger occurs, all the enabled channels do acquire an event asynchronously from any valid trigger event received in the meantime, overrunning other trigger conditions.
  - *Normal*: Event acquisition from all the enabled channels takes place basing on the self-trigger capability (by setting *DC OFFSET* and *THRESHOLD*) and upon the Trigger Logic programmed in Sec. **9.4.1**.
  - *Auto*: The digitizer will accept all valid trigger events; if no valid trigger event is received during a factory preset time, a trigger event is be forced by a timer to see the traces of the enabled channels.
  - *External*: Sets the External Trigger mode; the digitizer will record the signals only if a valid logic level trigger (NIM/TTL) is received at the digitizer front panel TRG-IN input (see the digitizer User Manual).
- **Ext Trig Type:** Programs the digitizer to sense TTL or NIM trigger signals provided to TRG-IN.
- **Use Ext Trig as Gate:** The TTL or NIM signal on TRG-IN is used as Gate (i.e. it is in AND with the enabled channel self-triggers) for the acquisition of events. The self-trigger requests from the channels can still be logically combined as in Sec. **9.4.1**.

9.4.3 Trigger Threshold Settings

Note: These settings are effective only in case of *TRIGGER TYPE* = *Normal*.

- ***THRESHOLD*:** It is the level of the channel self-trigger discriminator; the specific channel to apply the threshold value is selected in the upper slide menu box. The threshold is expressed in Volts and ranges from -1.25 V to +1.25 V by the knob (coarse setting). A fine setting with the resolution of 0.001 V can be done through the *Up* and *Down* arrows. Using the *Apply to All* key permits to set the same threshold to all the enabled channels.

  The threshold value is referred to the analog offset of the channel (Sec. **9.2.2**), so each time *DC OFFSET* is changed, the threshold must be tuned accordingly to let the channel self-trigger. As *DC OFFSET* changes, the software automatically changes the threshold range in the tab.

Note: Consider that the real threshold is applied on the input signal (before offset application) with an effective range value between -1.25V and +1.25V.

- ***Edge*:** This setting decides whether the self-trigger must be generated when the threshold is crossed on the rising (left condition) or falling (right condition) edge of the input pulse. The *Apply to All* key allows the user to apply the same setting to all the enabled channels.

10 System Messages Section

This 3-tab section at bottom-left side of the WaveCatcher Main Frame (**Fig. 6.1**), gives the user a feeling on the operations being done, displaying a chronological list of the performed actions and the relevant board status as well as warnings and errors.

The information displayed in the Info tab is saved to the *logfile.txt* file at:

C:\Users\<USER>\AppData\Local\CAENWaveCatcher

10.1 Infos Tab

Displays all kind of info messages, including warnings and errors.

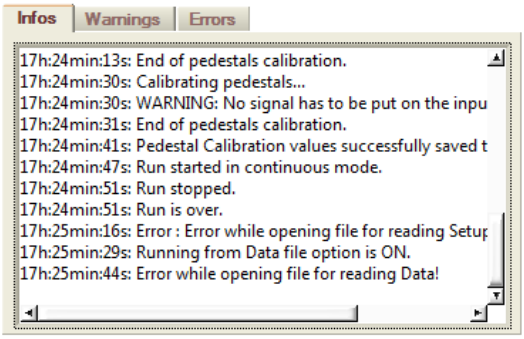


Fig. 10.1: Infos tab

10.2 Warnings Tab

Displays the warning messages only.

Fig. 10.2: Warnings tab

10.3 Errors Tab

Displays the error messages only.

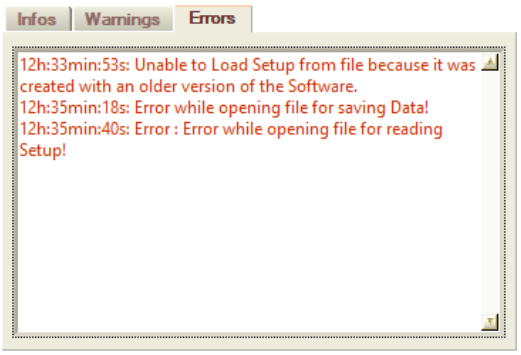


Fig. 10.3: Errors tab

11 Output Files

In the WaveCatcher software, a set of output files can be generated by the supported save options, useful for parameter configuration backup, data recording purposes or offline analysis. Some saved files can then be imported in the software by recall options and used as configuration pre-set or for offline runs (Chap. **7**).

11.1 Setup File

		Notes
Save Option	*Menu Bar → Configuration → Save Setup to File*	**Fig. 7.3**.
File Name	*Setup_*.dat*	"*" must be personalized by the user.
File Type	*Binary*	WaveCatcher structure code.
Default Path	*C:\Users\<USER>\AppData\Local\CAENWaveCatcher\Setup*	User selectable.
Recall Option	*Menu Bar → Configuration → Load Setup from File*	**Fig. 7.3**. The Setup file must have been saved with the same version of the software that is used for recall.

Tab. 11.1: Setup file info table

11.1.1How to Save

1. Click on the *Save Setup to File* item in the Menu Bar or the related icon in the Icon Bar (Chap. **8**).

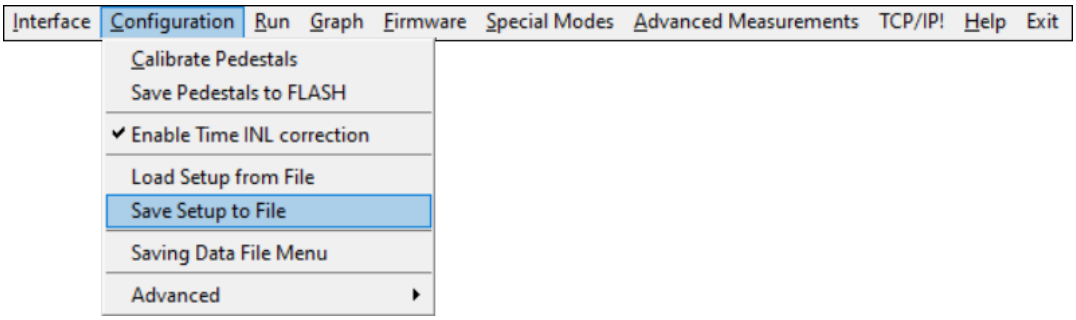


Fig. 11.1: Save Setup File function in the Menu Bar

2. Digit the file name in the opening Windows API.
3. Confirm the file destination path or select a different one on the host computer or storage peripheral.

11.1.2How to Recall

1. Click on the *Load Setup from File* item in the Menu Bar or the related icon in the Icon Bar (Chap. **8**).

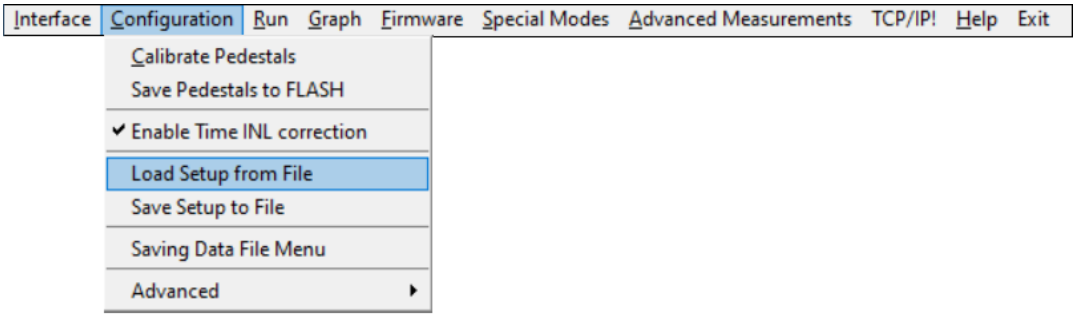


Fig. 11.2: Recall Setup File function in the Menu Bar

2. Search and load the file by the opening Windows API.

11.1.3File Format

The file contains binary information in the WaveCatcher structure code, except for the software version reported in ASCII format, and can only be managed by the WaveCatcher itself.

11.2 Run Data Files

		Notes
Save Options	*Menu Bar → Run → Save Run to File → Save Waveforms only* *Menu Bar → Run → Save Run to File → Save Waveforms & Measurements* *Menu Bar → Configuration → Saving Data file Menu*	**Fig. 7.5** and **Fig. 7.8**.
File Name	*wavecatcher_11282022_14h07min_run1_Ascii*	*wavecatcher* = basename; *mm_dd_yyyy* = system date; *hh_mm* = system time; *run(n)* = run ID; *Ascii/Bin* = file format.
File Type	*ASCII* or *Binary*	Software selectable.
Default Path	*C:\Users\<USER>\AppData\Local\CAENWaveCatcher\Run_Data*	User selectable.
Recall Option	*Menu Bar → Run → Run from File*	**Fig. 7.3**.

Tab. 11.2: Waveforms file info table

11.2.1How to Save

1. Click on the *Save Waveforms Only* or *Save Waveforms & Measurements* item in the WaveCatcher Menu Bar.

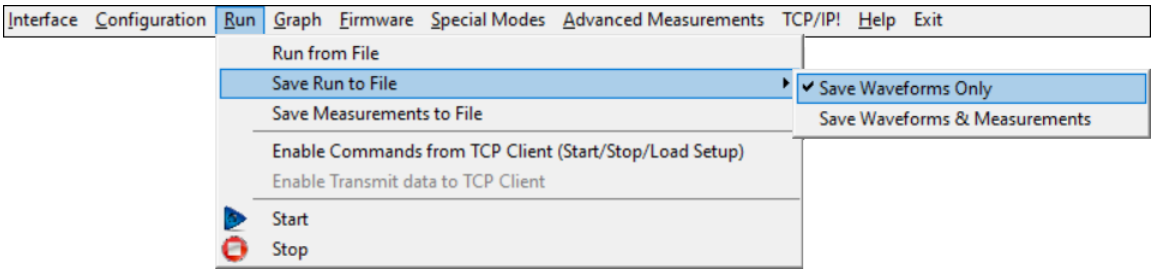


Fig. 11.3: Save Run Data File selection

2. Click on the *Saving Data File Menu* item in the WaveCatcher Menu Bar.

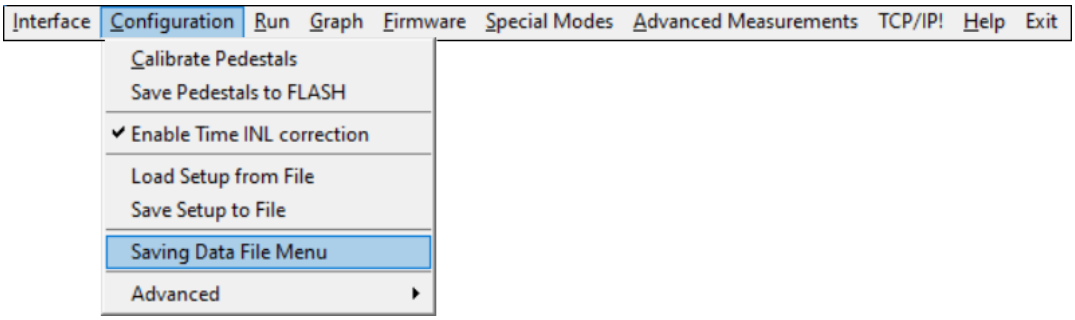


Fig. 11.4: Output Data file settings selection

3. Select the type and name options for the output data file in the Dialog Box (**Fig. 7.5**).
4. Preferably set the run in a Finite Mode, as Continuous Mode involves a huge amount of data (Sec. **9.1.3**).
5. Start the acquisition.
6. Customize the file name in the opening Windows API.
7. Confirm the file destination path or select a different one on the host computer, or storage peripheral.

11.2.2How to Recall

1. Click on the *Run from File* item in the WaveCatcher Menu Bar.

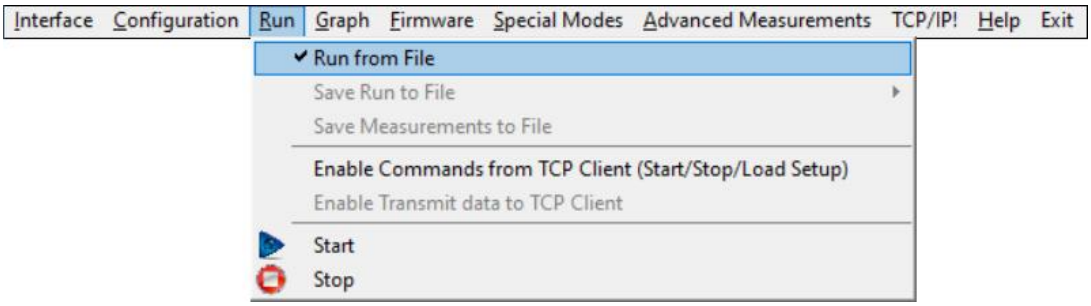


Fig. 11.5: Recall Run Data File selection

2. Start the acquisition.
3. Search and load the file by the Windows API.

11.2.3File Format

ASCII Format

- ***Save Waveforms Only*:** the first part of the ASCII output file is a header (software version, board info, other parameters) then followed by the data per channel (time info, run parameters, wave samples) ordered by event number.

  For a single channel enabled, 2-event Finite Run Mode, recording depth of 64 samples, the output file format is as follows:

=== DATA FILE SAVED WITH SOFTWARE VERSION: V1.8.5 ===

=== CAEN DIGITIZER BOARD TYPE x743 WITH 8 CHANNELS AND GAIN: 1.0 ===

=== Other Parameters ===

=== DATA SAMPLES [64] in Volts == NB OF CHANNELS ACQUIRED: 1 == Sampling Period: 312.5 ps == INL Correction: 1 ===

=== EVENT 1 ===

=== UnixTime = 1417101451.265 date = 2014.11.27 time = 16h.17m.31s.265ms == TDC From FPGA = 289728 == TDC Corrected = 16h17m31s,001.448.640ns ===

=== CH: 0 EVENTID: 1 FCR: 464 Baseline: 0.000000 V Amplitude: 0.000000 V Charge: 0.000 pC LeadingEdgeTime: 0.000 ns TrailingEdgeTime: 0.000 ns TrigCount: 17 TimeCount 1228 ===

-0.001155 -0.001220 -0.001113 -0.000319 -0.001539 -0.001081 -0.000262 0.000267 -0.000217 -0.000791 0.000214 -0.000053 -0.001136 -0.000763 0.001073 0.001263 0.001166 0.000933 0.000017 -0.001477 -0.000685 0.000338 -0.000918 -0.000035 -0.000304 0.000001 -0.000250 -0.000443 0.000089 -0.000102 0.000290 -0.000452 -0.001008 0.000300 0.000370 -0.000738 -0.001076 0.000909 0.000177 0.001638 0.000231 -0.000843 0.000458 -0.000538 0.000038 -0.000459 -0.000081 -0.001679 -0.000198 0.000598 -0.001066 -0.000421 -0.001007 -0.000966 0.000058 0.000542 0.001535 0.001112 0.002049 0.000776 -0.000892 -0.001122 -0.000282 -0.000320

=== EVENT 2 ===

=== UnixTime = 1417101451.275 date = 2014.11.27 time = 16h.17m.31s.275ms == TDC From FPGA = 304194 == TDC Corrected = 16h17m31s,001.520.970ns ===

=== CH: 0 EVENTID: 2 FCR: 192 Baseline: 0.000000 V Amplitude: 0.000000 V Charge: 0.000 pC LeadingEdgeTime: 0.000 ns TrailingEdgeTime: 0.000 ns TrigCount: 0 TimeCount 6 ===

-0.000588 0.000227 -0.000385 0.000692 0.000999 0.000467 0.000643 0.001506 0.001092 0.000594 0.000079 0.000038 -0.000764 0.000144 0.000498 -0.000267 0.000463 0.000267 0.000191 -0.000453 -0.000690 -0.000261 0.001196 0.000538 0.001142 0.000544 0.000575 0.002028 0.001351 0.000852 0.000145 0.000495 0.000115 -0.000118 0.000573 -0.000220 -0.000246 -0.001101 -0.000311 -0.001018 -0.000546 -0.002283 -0.000797 0.000047 0.000028 -0.000646 -0.001311 -0.001326 -0.000948 -0.000496 -0.000538 -0.000047 0.000081 -0.000250 0.001007 0.000333 -0.000763 0.000452 -0.000564 -0.000724 -0.000496 -0.000454 0.000414 0.001013

- ***Save Waveforms & Measurements*:** the run data saved are the waveforms as well as the parameters from the Time Measurements (Sec. **7.7.3**) and the Charge Measurements (Sec. **7.6.2**); the first part of the ASCII output file is a Header (software version, board info, other parameters) then followed by the data (time info, run parameters, wave samples and measurements parameters) ordered by event number

  For a single channel enabled, 2-event Finite Run Mode, recording depth of 64 samples, the output file format is following reported:

=== DATA FILE SAVED WITH SOFTWARE VERSION: V1.8.5 ===

=== CAEN DIGITIZER BOARD TYPE x743 WITH 16 CHANNELS AND GAIN: 1.0 ===

=== Other Parameters ===

=== DATA SAMPLES [64] in Volts == NB OF CHANNELS ACQUIRED: 1 == Sampling Period: 312.5 ps == INL Correction: 1

=== EVENT 1 ===

=== UnixTime = 1669641860.489 date = 2022.11.28 time = 14h.24m.20s.489ms == TDC From FPGA = 354800 == TDC Corrected = 14h24m20s,001.774.000ns ===

=== CH: 0 EVENTID: 1 FCR: 864 Baseline: 0.001230 V Amplitude: 0.263754 V Charge: 258.123 pC LeadingEdgeTime: 1774231.169 ns TrailingEdgeTime: 1774281.167 ns TrigCount: 2 TimeCount 2493 ===

0.002430 0.001944 0.001524 0.001841 0.000588 0.001144 0.000495 0.001174 0.000831 0.002065 0.002503 0.000523 0.000255 -0.000712 0.001460 0.001608 0.004138 0.003305 0.002613 0.001415 0.001575 0.000731 0.001277 0.001377 0.003072 0.003964 0.001586 0.001527 0.001787 0.001233 0.000229 0.001158 0.001798 0.001476 0.000343 0.001486 0.000643 0.001828 0.000615 0.001737 0.001230 0.001232 0.003048 0.001437 0.000119 0.000728 0.002514 0.001397 0.003391 0.002684 0.001331 0.001402 0.001949 0.002673 0.001757 0.001817 0.003221 0.003338 0.002507 0.002037 ……

=== EVENT 2 ===

=== UnixTime = 1669641860.489 date = 2022.11.28 time = 14h.24m.20s.489ms == TDC From FPGA = 754800 == TDC Corrected = 14h24m20s,003.774.000ns ===

=== CH: 0 EVENTID: 2 FCR: 368 Baseline: 0.001811 V Amplitude: 0.262926 V Charge: 260.575 pC LeadingEdgeTime: 3774223.231 ns TrailingEdgeTime: 3774273.213 ns TrigCount: 0 TimeCount 113 ===

0.001144 0.001403 0.000762 0.001372 0.000804 0.001129 0.001614 0.001927 0.002242 0.003864 0.003332 0.002772 0.001282 0.000650 0.002393 0.002293 0.001867 0.002138 0.000536 0.001719 0.002174 0.003017 0.003097 0.002141 0.001938 0.001005 -0.000087 0.002078 0.003580 0.002889 0.001605 0.002021 0.001562 0.001825 0.002709 0.002109 0.001771 0.002830 0.0026120.002462 0.001975 0.001416 0.001708 0.001949 0.001416 0.001372 0.001294 0.001602 ……

Binary Format

The first part of the Binary output file is a 5-line ASCII header, then followed by the binary code.

=== DATA FILE SAVED WITH SOFTWARE VERSION: VX.X ===

=== CAEN DIGITIZER BOARD TYPE x743 WITH 8 CHANNELS AND GAIN: 1.0 ===

=== Other Parameters ===

=== DATA SAMPLES [1024] in Volts == NB OF CHANNELS ACQUIRED: 8 == Sampling Period: 312.5 ps == INL Correction: 1 ===

To decode the Binary file, two main steps are needed:

- *1st Step*: NB OF CHANNELS ACQUIRED in the header gives the number of acquired channels which must be read in order to decode the rest of the file (to be used for *nbOfChannelsInFile* below).
- *2nd Step*: for each event, the following C function must be used to decode:

```
if(fread (&EventNumber, sizeof(int), 1, FileForLoadingDataPntr)==0)
            return 0;  // Reached End Of File;
fread (&EpochTime, sizeof(double), 1, FileForLoadingDataPntr);
fread (&Year, sizeof(unsigned int), 1, FileForLoadingDataPntr);
fread (&Month, sizeof(unsigned int), 1, FileForLoadingDataPntr);
fread (&Day, sizeof(unsigned int), 1, FileForLoadingDataPntr);
fread (&Hour, sizeof(unsigned int), 1, FileForLoadingDataPntr);
fread (&Minute, sizeof(unsigned int), 1, FileForLoadingDataPntr);
fread (&Second, sizeof(unsigned int), 1, FileForLoadingDataPntr);
fread (&uint_millisecond, sizeof(unsigned int), 1, FileForLoadingDataPntr);
```

```
– Millisecond = (double)uint_millisecond;
– fread (TDC, sizeof(unsigned __int64), 1,FileForLoadingDataPntr);
– fread (EventTimeChain, sizeof(char), 23,FileForLoadingDataPntr);
– for(chIndex = 0; chIndex <nbOfChannelsInFile; chIndex ++)
–         {
–             fread (&rdChannel, sizeof(int), 1,FileForLoadingDataPntr);
–             samIndex = (int)rdChannel/2;
–             channel = rdChannel%2;  // this channel is modulo 2 inside the samIndex
–             fread (&eventId, sizeof(int), 1,FileForLoadingDataPntr);
–             EventID[samIndex]= eventId;
–             fread (&fcr, sizeof(int), 1,FileForLoadingDataPntr);
–             FirstCellToPlot[samIndex]; // this field is not need for user
–             fread (&baseline,  sizeof(float), 1,FileForLoadingDataPntr);
–             fread (&charge, sizeof(float), 1,FileForLoadingDataPntr);
–             fread   (&absoluteRiseTimeInstant,   sizeof(double),   1,FileForLoadingDataPntr);   //
    timtestamp of the rising edge in nanoseconds from beginning of the run
–             fread   (&absoluteFallTimeInstant,   sizeof(double),   1,FileForLoadingDataPntr);   //
    timtestamp of the rising edge in nanoseconds from beginning of the run
–
–             fread (&amplitude, sizeof(float), 1,FileForLoadingDataPntr);
–             fread (&trigcount, sizeof(int), 1, FileForLoadingDataPntr);
–             fread (&timecount, sizeof(int), 1, FileForLoadingDataPntr);
–             TrigCount[samIndex][channel]= (unsigned short)trigcount;
–             TimeCount[samIndex][channel]= (unsigned short)timecount;
–             fread               (DataTempBuffer,              sizeof(signed              short),
    AcqParams.NbOfSamplesInFile,FileForLoadingDataPntr);
–             for(n= 0; n<AcqParams.NbOfSamplesInFile; n++)
–             {   Waveform[samIndex][channel][n]= (float)DataTempBuffer[n]/10.0;   }
```

Here waveform data is in ADC counts, to convert it to Volts, the samples must be multiplied by the constant factor **ADCTOVOLTS = 0.00061**

Time Information

The time information in the Binary and ASCII output files is following described.

- *UnixTime/EpochTime*: this is the Unix Time at which the software receives the data;
- *date* (Year, Month, Day) and *time* (Hour, Minute, Second, Millisecond): it is the *UnixTime/EpochTime* converted to year/month/day/hours/min/sec, so it is not the precise time of the waveform, but rather a rough estimation of the time the waveform data were received in the software;
- *TDC From FPGA*: this is the very precise absolute time of the waveform sent by the FPGA; it is a counter that counts at *sampling_periode* * 16; this TDC is reset at the beginning of the Run by a *Sync_command* (sent by the software);
- *Time Corrected*: it is the sum of the TDC value from the FPGA and the date (Year, Month, Day, Hour, Minute, Second, Millisecond) of the *sync_command*. This gives a very good estimation of the real waveform absolute time (with a little offset, which is the time offset between the time the *sync_command* arrived to the FPGA and the date it is tagged in the software code by the *getSystemDate* C function).

Hit Rate Information

The Run Data output files contain information related to the on-board channel Hit Monitor (see the digitizer User Manual). For each channel:

- *TrigCount* is a raw trigger counter counting the number of hits crossing the programmed discriminator threshold between two acquired events.
- *TimeCount* counts the time elapsed with a 1-MHz clock.

As soon as the first of the two saturates, both counters are frozen. For instance, if the delay between two acquired events is too big (i.e. *TimeCount* saturates), then *TrigCount* will stop when the *TimeCount* stops, as the latter reached its maximum value.

In the end, the two counters make possible to have the raw trigger rate on each channel independently on the rate of the acquisition (which can be seen in the event counter).

The Hit Rate vs Threshold plot in WaveCatcher is based on *TrigCount* and *TimeCount* (Sec. **7.7.4**).

11.3 Measurements File

		Notes
Save Option	*Menu Bar → Run → Save Measurements to File*	**Fig. 7.7**.
File Name	*measurements_wavecatcher_11282022_15h03min_run12_Ascii.dat*	*measurements* = fixed prefix; *wavecatcher* = basename; *mm_dd_yyyy* = system date; *hh_mm* = system time; *run(n)* = run ID; *Ascii/Bin* = file format.
File Type	*ASCII*	
Default Path	*C:\Users\<USER>\AppData\Local\CAENWaveCatcher\Run_Data*	User selectable.
Recall Option	-	Not supported.

Tab. 11.3: Measurements file info table

11.3.1 How to Save

1. Click on *Save Measurements to File* item in the Menu Bar.

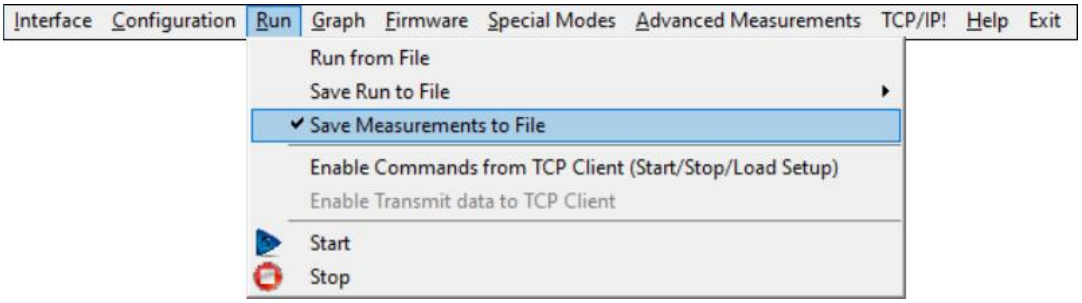


Fig. 11.6: Save Measurements to File selection

2. Customize the file name in the Windows API.
3. Confirm the file destination path or select a different one on the host computer or storage peripheral.

11.3.2 How to Recall

Recalling Measurements Only output files is not supported.

11.3.3 File Format

For a single channel enabled, 1-event run in Finite Mode, 1024 samples of recording depth, the output file format is following reported:

```
=== DATA FILE SAVED WITH SOFTWARE VERSION: V1.8.5 ===

=== CAEN DIGITIZER BOARD TYPE x743 WITH 16 CHANNELS AND GAIN: 1.0 ===

=== Other Parameters ===

=== ChannelNb MeasuredBaseline[Volts] Amplitude[Volts] Charge[pC] LeadingEdgeTime[ns] TrailingEdgeTime[ns] ===

=== Event 1 UnixTime = 1669644189.756 date = 2022.11.28 time = 15h.3m.9s.756ms == TDC From FPGA = 2190862 == TDC Corrected = 15h03m09s,010.954.310ns ===

0 0.000138 -0.002069   -0.169 10954310.184 10954310.431
```

Where:

– *ChannelNb* is the channel identifier

- *MeasuredBaseline* is the calculated baseline.
- *Amplitude* is the peak of the waveform (can be positive or negative).
- *Charge* is computed by integration over the entire waveform with baseline extraction
- *LeadingEdge Time/TrailingEdge Time* are computed on the settings of the Time Measurements dialog box (Sec. **7.7.3**).

11.4 Charge Histograms File

		Notes
Save Option	*Menu Bar → Special Modes → Charge Mode → Show Histogram → Save Histos*	**Fig. 7.19**
File Name	*Run_*_ChargeHistos_mm_dd_yyyy.dat*	"*" must be personalized by the user; *mm_dd_yyyy* is written by the software.
File Type	*ASCII*	
Default Path	*C:\Users\<USER>\AppData\Local\CAENWaveCatcher\Histos*	User selectable.
Recall Option	-	Not supported.

Tab. 11.4: Charge Histograms file info table

11.4.1How to Save

1. Click on the *Charge Mode* item in the Menu Bar.

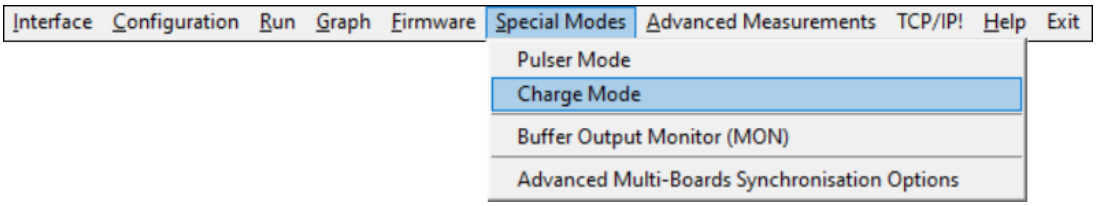


Fig. 11.7: Save Charge Histograms File selection: step 1

2. Click on the *Show Histogram* key in the Charge Measurement Panel (**Fig. 7.17**).
3. Click on the *Save Histos* key in the Charge Histogram dialog box (**Fig. 7.19**).
4. Customize the file name in the Windows API.
5. Confirm the file destination path or select a different one on the host computer, or storage peripheral.

11.4.2How to Recall

Recalling Charge Histograms output files is not supported.

11.4.3File Format

For a single channel enabled, Continuous Run Mode, 1024 samples of recording depth, the charge histogram output file format is following reported:

=== CHARGE HISTOs ===

== CHANNEL : 0 ==

== Nb Of Entries in Histogram : 256 ==

== X AXIS : Charge in pico-Coulombs [100 values] ==

-231.073 -229.909 -228.746 -227.583 -226.420 -225.257 -224.094 -222.930 -221.767 -220.604 -219.441 -218.278 -217.114 -215.951 -214.788 -213.625 -212.462 -211.298 -210.135 -208.972 -207.809 -206.646 -205.483 -204.319 -203.156 -201.993 -200.830 -199.667 -198.503 -197.340 -196.177 -195.014 -193.851 -192.687 -191.524 -190.361 -189.198 -188.035 -186.871 -185.708 -184.545 -183.382 -182.219 -181.056 -179.892 -178.729 -177.566 -176.403 -175.240 -174.076 -172.913 -171.750 -170.587 -169.424 -168.260 -167.097 -165.934 -164.771 -163.608 -162.444 -161.281 -160.118 -158.955 -157.792 -156.629 -155.465 -154.302 -153.139 -151.976 -150.813 -149.649 -148.486 -147.323 -146.160 -144.997 -143.833 -142.670 -141.507 -140.344 -139.181 -138.018 -136.854 -135.691 -134.528 -133.365 -132.202 -131.038 -129.875 -128.712 -127.549 -126.386 -125.222 -124.059 -122.896 -121.733 -120.570 -119.406 -118.243 -117.080 -115.917

== Y AXIS : Charge Distribution [100 values] ==

0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 2 29 78 204 385 634 915 1263 1451 1607 1833 1968 2048 2041 2081 1934 1922 1933 1887 1793 1749 1655 1578 1529 1472 1398 1331 1223 1179 1022 994 950 880 773 720 713 593 534 518 442 397 367 358 284 266 220 207 208 154 134 117 103 80 72 74 59 54 39 50 38 24 17 15 19 18 11 9 3 6 6 5 3 2 2 1 2 0 1

== Mean Charge = -181.011 [pico-Coulombs] ==

== Charge Sigma = 12.766 [pico-Coulombs rms] ==

11.5 Time Histograms File

		Notes
Save Option	*Menu Bar → Advanced → Time Measurements → Time Distance Histogram → Save Histo*	**Fig. 7.19**
File Name	*Run_*_TimeHistos_mm_dd_yyyy.dat*	"*" must be personalized by the user; *mm_dd_yyyy* is written by the software.
File Type	*ASCII*	
Default Path	*C:\Users\<USER>\AppData\Local\CAENWaveCatcher\Histos*	User selectable.
Recall Option	-	Not supported.

Tab. 11.5: Time Histograms file info table

11.5.1How to Save

1. Click on the *Time Measurements* item in the WaveCatcher Menu Bar.

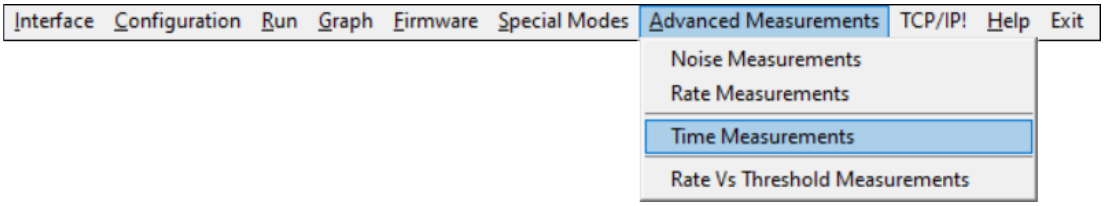


Fig. 11.8: Save Time Histograms File selection: step 1

2. Click on the *Time Distance Histogram* key in the Time Measurements dialog box (**Fig. 7.25**).
3. Click on the *Save Histo* key in the Time Measurement Histogram dialog box (Errore. L'origine riferimento non è stata trovata.).
4. Customize the file name in the Windows API.
5. Confirm the file destination path or select a different one on the host computer or storage peripheral.

11.5.2How to Recall

Recalling Time Histograms output files is not supported.

11.5.3File Format

For two channels enabled, Continuous Run Mode, 1024 samples of recording depth, the Time Distance histogram output file format is following reported:

=== TIME DIFFERENCE DISTRIBUTION BETWEEN CHANNEL [0] AND CHANNEL [1] ON 13800 EVENTS ===

== X AXIS : Time difference between pulses in ns [100 values] ==

-593.49752 -583.81788 -574.13824 -564.45859 -554.77895 -545.09931 -535.41967 -525.74003 -516.06039 -506.38075 -496.70111 -487.02147 -477.34183 -467.66219 -457.98254 -448.30290 -438.62326 -428.94362 -419.26398 -409.58434 -399.90470 -390.22506 -380.54542 -370.86578 -361.18614 -351.50650 -341.82685 -332.14721 -322.46757 -312.78793 -303.10829 -293.42865 -283.74901 -274.06937 -264.38973 -254.71009 -245.03045 -235.35081 -225.67116 -215.99152 -206.31188 -196.63224 -186.95260 -177.27296 -167.59332 -157.91368 -148.23404 -138.55440 -128.87476 -119.19511 -109.51547 -99.83583 -90.15619 -80.47655 -70.79691 -61.11727 -51.43763 -41.75799 -32.07835 -22.39871 -12.71907 -3.03942 6.64022 16.31986 25.99950 35.67914 45.35878 55.03842 64.71806 74.39770 84.07734 93.75698 103.43663 113.11627 122.79591 132.47555 142.15519 151.83483 161.51447 171.19411 180.87375 190.55339 200.23303 209.91267 219.59232 229.27196 238.95160 248.63124 258.31088 267.99052 277.67016 287.34980 297.02944 306.70908 316.38872 326.06836 335.74801 345.42765 355.10729 364.78693

== Y AXIS : Time Distribution [100 values] ==

0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 4 1 1 0 0 0 1 0 2 1 0 2 2 1 1 1 2 1 2 3 6 7 13 23 21 32 53 107 246 518 1473 4786 6104 386 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

== Mean of time distance between Pulses = 27.15210 [ns] ==

== RMS of time distance between Pulses = 14950.508 [ps] ==

== FWHM of time distance between Pulses = 19912.432 [ps] ==

== After Gaussian fit: ==

== Fitted Mean of time distance between Pulses = 0.00000 [ns] ==

== Sigma (fit) of time distance between Pulses = 0.000 [ps] ==

== FWHM (fit) of time distance between Pulses = 0.000 [ps] ==

11.6 Hit Rate vs Threshold Data File

		Notes
Save Option	*Menu Bar → Advanced → Rate vs Threshold Measurements → Save Results to File*	**Fig. 7.28**
File Name	*Run_*_RateVsThreshold_mm_dd_yyyy.dat*	"*" must be personalized by the user; *mm_dd_yyyy* is written by the software.
File Type	*ASCII*	
Default Path	*C:\Users\<USER>\AppData\Local\CAENWaveCatcher\OtherMeasurements*	User selectable.
Recall Option	-	Not supported.

Tab. 11.6: Hit Rate vs Threshold Data file info table

11.6.1.1 How to Save

1. Click on the *Rate vs Threshold Measurements* item in the WaveCatcher Menu Bar.

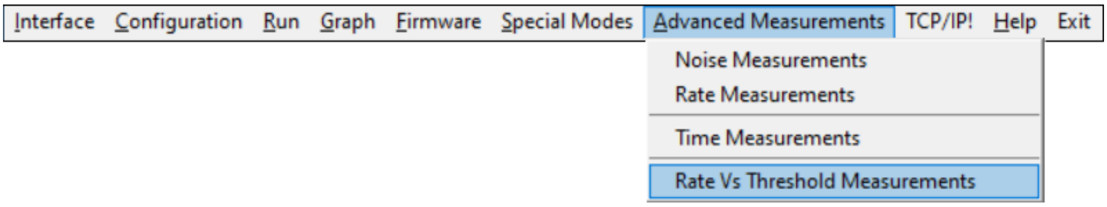


Fig. 11.9: Save Hit Rate vs Threshold Data File selection

2. Click on the *Save Results to File* key in the Hit Rate VS Threshold Plot dialog box (**Fig. 7.28**).
3. Customize the file name in the Windows API.
4. Confirm the file destination path or select a different one on the host computer or storage peripheral.

11.6.1.2 How to Recall

Recalling Hit Rate vs Threshold output files is not supported.

11.6.1.3 File Format

For a single channel enabled, Continuous Run Mode, 1024 samples of recording depth, the Hit Rate vs Threshold data output file format is following reported:

== RATE VS THRESHOLD WITH NB OF ELEMENTS : 99 ==

== X AXIS: THRESHOLD VALUES [VOLTS] ==

-1.2500 -1.2245 -1.1990 -1.1735 -1.1480 -1.1224 -1.0969 -1.0714 -1.0459 -1.0204 -0.9949 -0.9694 -0.9439 -0.9184 -0.8929 -0.8673 -0.8418 -0.8163 -0.7908 -0.7653 -0.7398 -0.7143 -0.6888 -0.6633 -0.6378 -0.6122 -0.5867 -0.5612 -0.5357 -0.5102 -0.4847 -0.4592 -0.4337 -0.4082 -0.3827 -0.3571 -0.3316 -0.3061 -0.2806 -0.2551 -0.2296 -0.2041 -0.1786 -0.1531 -0.1276 -0.1020 -0.0765 -0.0510 -0.0255 0.0000 0.0255 0.0510 0.0765 0.1020 0.1276 0.1531 0.1786 0.2041 0.2296 0.2551 0.2806 0.3061 0.3316 0.3571 0.3827 0.4082 0.4337 0.4592 0.4847 0.5102 0.5357 0.5612 0.5867 0.6122 0.6378 0.6633 0.6888 0.7143 0.7398 0.7653 0.7908 0.8163 0.8418 0.8673 0.8929 0.9184 0.9439 0.9694 0.9949 1.0204 1.0459 1.0714 1.0969 1.1224 1.1480 1.1735 1.1990 1.2245 1.2500

== Y AXIS : RATE VALUES [HZ] FOR CHANNEL : 0 ==

0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 8919 9082 54071782 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

---

12 Exit Methods

Before quitting the WaveCatcher software, it is recommended to complete the possible current acquisition so that no useful data is lost.

To exit the software, the user can optionally:

- **click on the *Exit* item** on the Menu Bar.

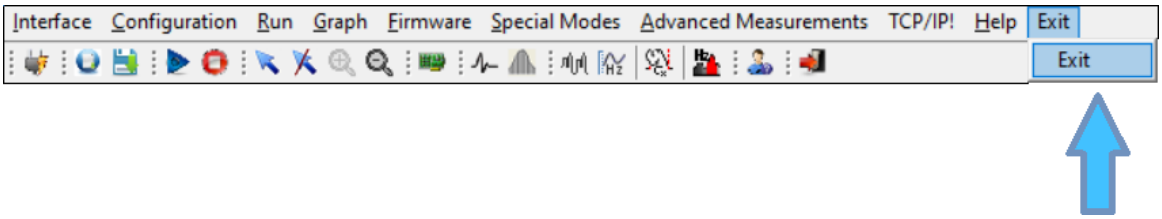


Fig. 12.1: Exit option 1

- **click on the *Exit* icon** on the Icon Bar.

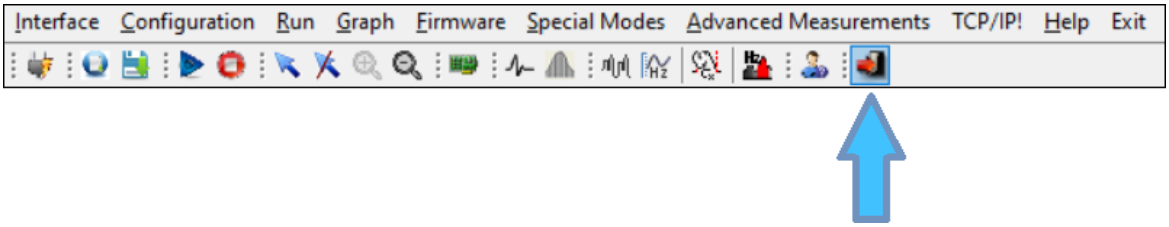


Fig. 12.2: Exit option 2

- **click on the *Close* key** on the Title Bar.

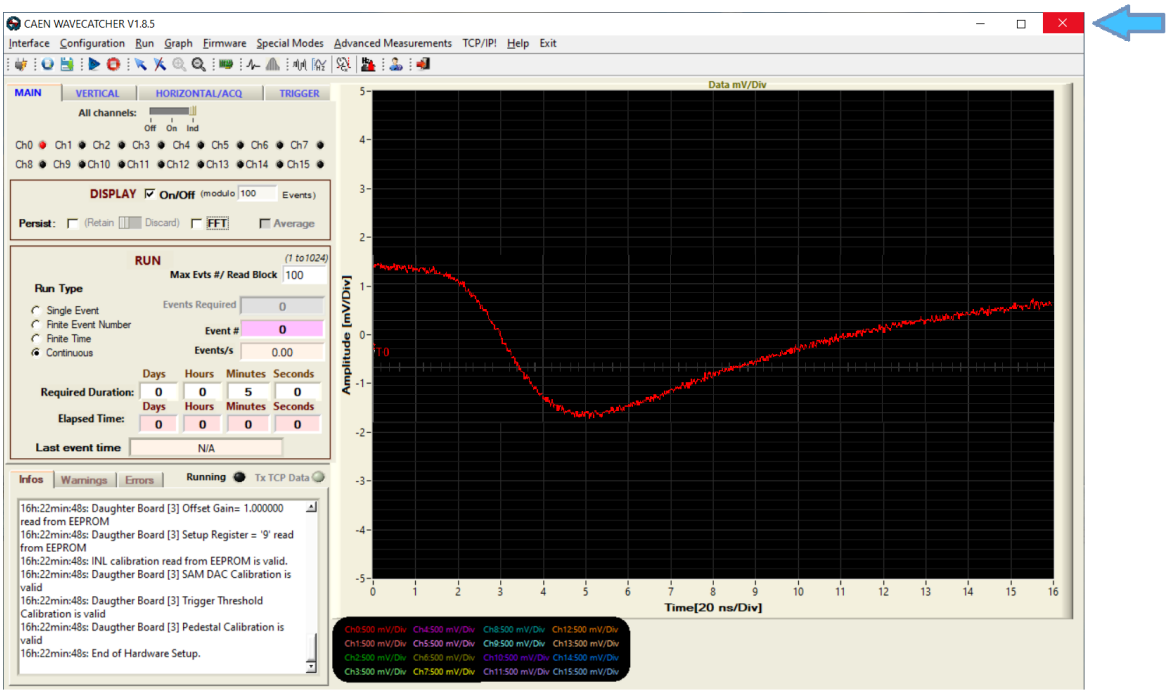


Fig. 12.3: Exit option 3

13 Getting Started

This section gives some examples of how to approach the WaveCatcher software to make basic operations on a x743 digitizer.

To initially set up the system, it is necessary to:

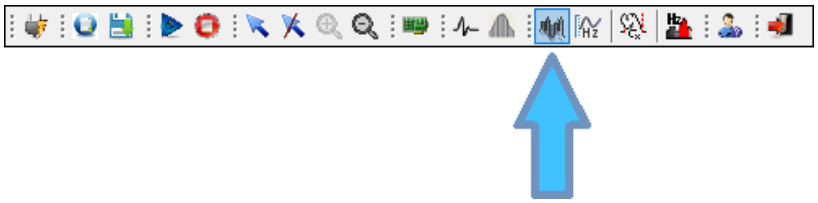
- Install the latest versions of the required driver and software on the host computer (Chap. **2**).
- Connect and initialize the target digitizer through the WaveCatcher software (Chap. **3**).

13.1 Pedestal Calibration

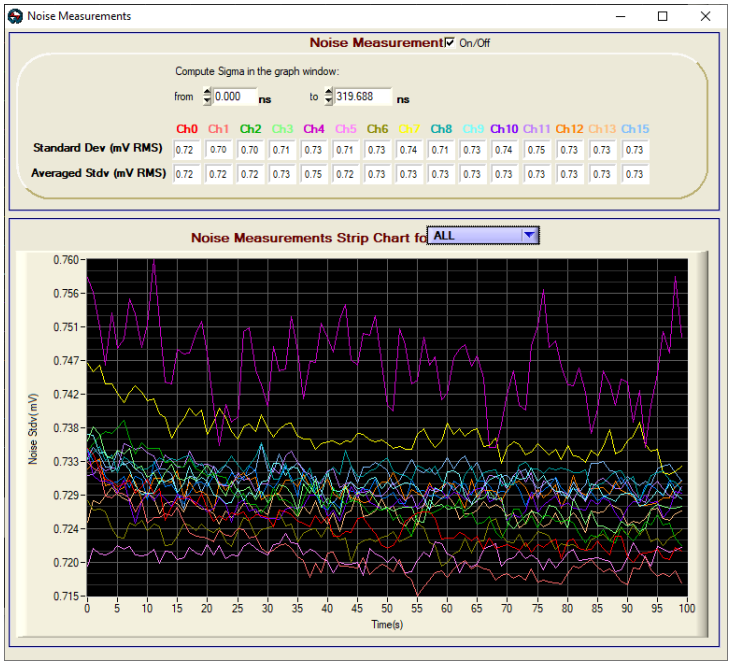
During the board initialization, the WaveCatcher loads the correction factors of all the kind of corrections stored in the on-board FLASH memory and required by the board **[RD1][RD2]**. Pedestals calibration is the only correction that can be performed by the User, if necessary.

Pedestals calibration must be executed with no signal on the input channels.

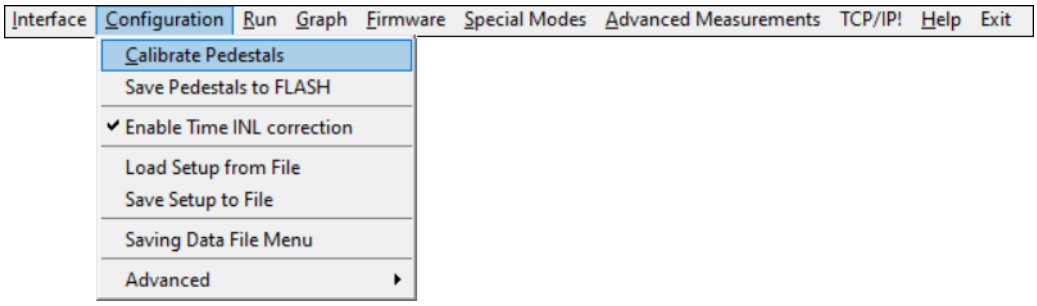
1. *Check the Noise Statistics*: Using this WaveCatcher function, helps to determine whether the pedestals calibration is needed or not.
   - Make sure to feed no signal in the input channels of the digitizer.
   - Do not change the channel DC offset; the default value will be used, putting the channel baseline around at middle scale of the ADC (Sec. **9.2.2**).
   - Select the Noise Measurements function in the Icon bar.



   - Keep the default settings in the Noise Measurements dialog box and start a Continuous Run in Software Trigger mode with all channels enabled (Chap. **9**).
   - Collect enough data in the Noise Measurements Strip Chart to monitor the standard deviation (Sigma) and its averaged value; if they stay beyond around 0.79 mV rms, then a pedestal calibration is required.

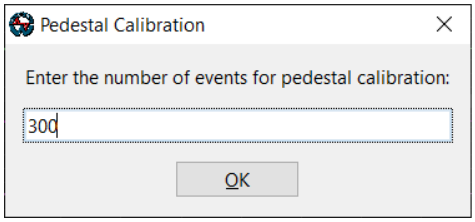


2. *Calibrate Pedestals*: Use this WaveCatcher function to calculate the new correction factors:
   - Access the Calibrate Pedestals function from the Menu bar.

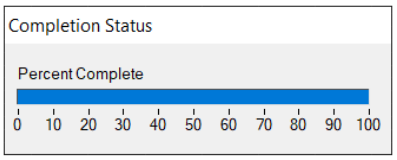


   - Set and confirm the number of samples of the channel baseline on which to calculate the calibration parameters.

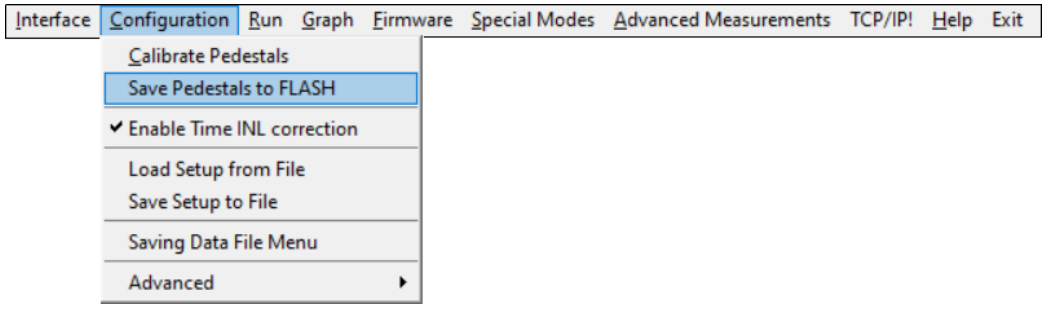
Note: A high number of events used for the pedestal calibration will ensure a better evaluation of the actual pedestal value but will require longer time for the pedestal calibration processing; a value of 300 samples is typically a good compromise.



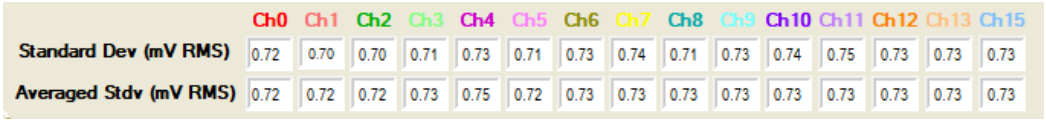
   - A progress pop-up window informs on the state of the completion.



3. *Save Pedestals to FLASH:* use this function to write the calculated correction factors in the digitizer FLASH:
   - Execute the Save Pedestal to FLASH function by the Menu bar.



   - Close and re-open WaveCatcher to make the software load the new correction factors from the digitizer FLASH.
   - Repeat the Noise Measurements and make sure that the Sigma and its averaged value stay below around 0.79 mV rms on all channels.



It is finally possible to connect all the signals to the digitizer input channels and step towards parameters tuning for the waveforms recording.

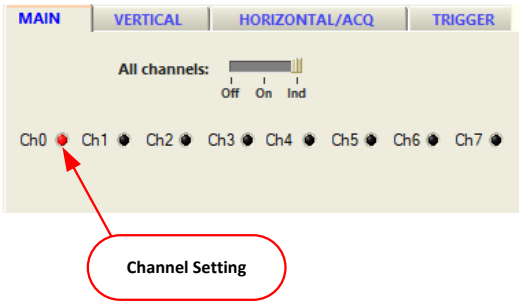
13.2 Waveforms Recording

This is an example of how to prepare for a single-channel waveform recording operation, where a fixed-frequency and fixed-amplitude negative pulse coming from a pulse generator is fed into channel 0 (Ch0) of the digitizer. After a first stage of parameters tuning, the digitizer can acquire events upon the channel self-trigger: each time the input pulse crosses the programmed discriminator threshold on channel 0, a trigger occurs causing an event to be stored in the digitizer memory and read out by the software (see the digitizer User Manual). Acquired events are saved to file.

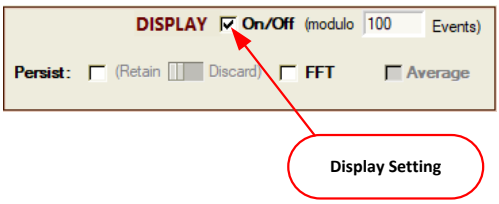
13.2.1 Forcing the Acquisition

Depending on the features of the input signal, the firmware/software default values do not guarantee the digitizer to be able to self-trigger. Forcing the acquisition helps to start tuning the required parameters.

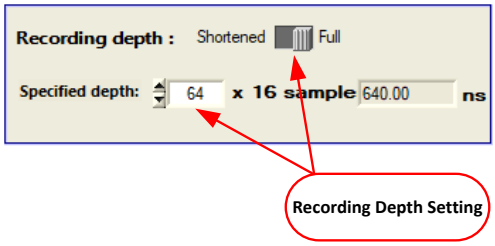
1. *Enable the Channels*: Check the *Ch0* checkbox in the MAIN tab to enable channel 0 (p. **37**); the colour code is RED.



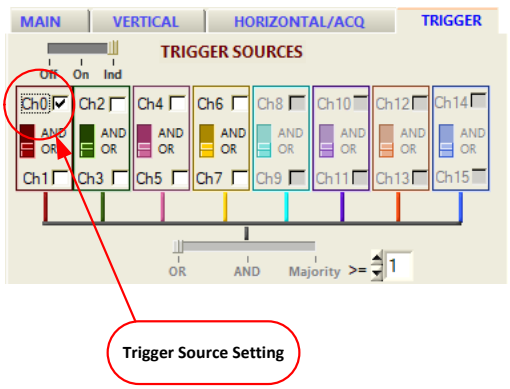
2. *Enable the Display*: Make sure that the *On/Off* checkbox is checked in the MAIN tab to enable the continuous plot in the Graph Display section (p. **37**).



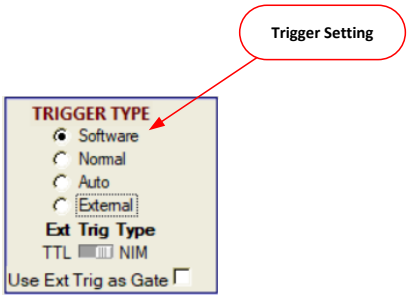
3. *Set the Recording Depth*: Set *Recording Depth* on *Full* in the HORIZONTAL/ACQ tab (p. **40**); a portion of the input signal made by 1024 samples (64 * 16) will be acquired per event.



4. *Enable the Trigger Source*: Make sure that the Ch0 checkbox is checked in the TRIGGER tab, so that the channel 0 self-triggers participate in the acquisition global trigger (p. **41**).

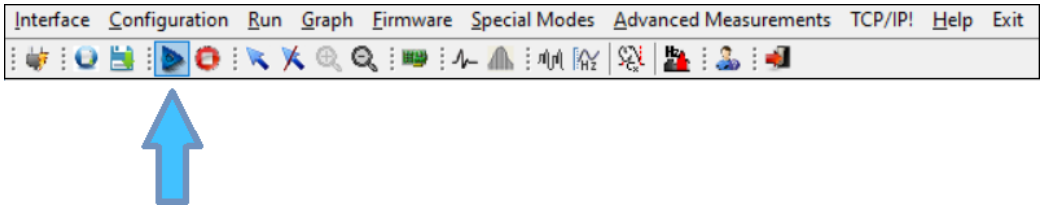


5. *Set the Software Trigger*: Set *TRIGGER TYPE* on *Software* in the TRIGGER tab to issue triggers by software command to the target digitizer.

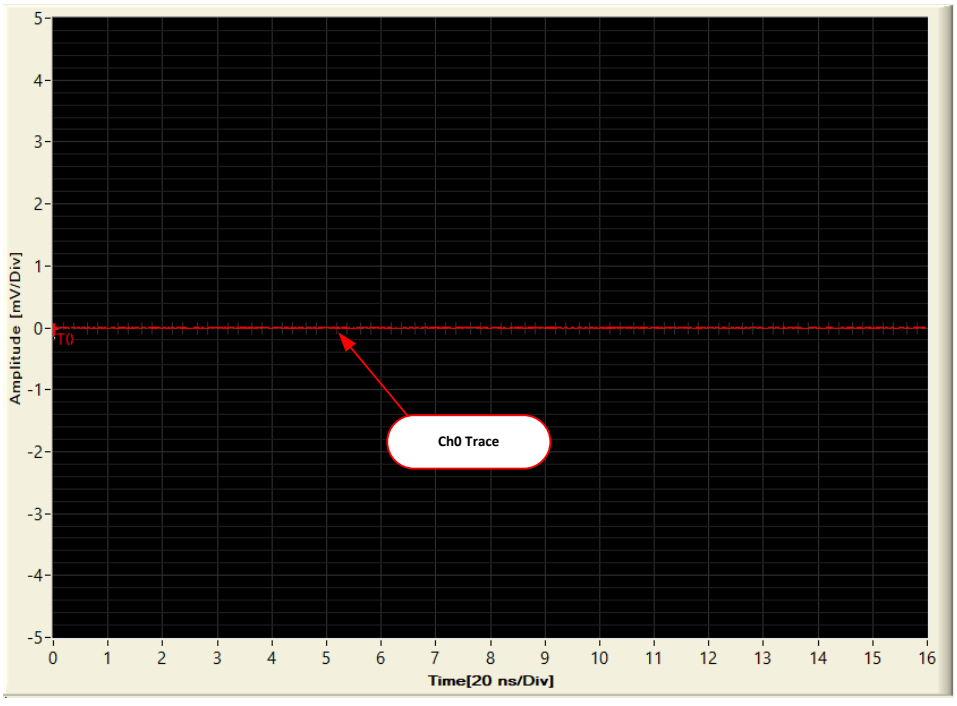


6. *Enable the Continuous Run*: Make sure that the *Continuous* checkbox is checked in the MAIN tab as Run option.

7. *Start the Acquisition*: Start the acquisition easily by the Icon bar.



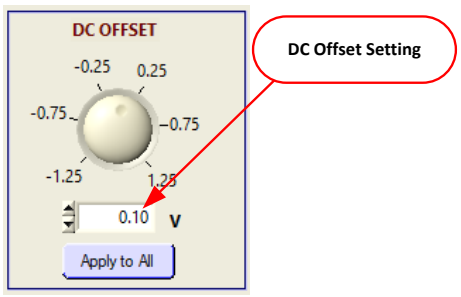
The digitizer enters the Run status (front panel green RUN LED is on) and starts triggering (front panel green TRG LED is on). The WaveCatcher shows a 320-ns red trace (1024 samples @ 3.2 GS/s) corresponding to channel 0 signals in the Graph Display.



13.2.2Tuning Parameters for Self-Trigger Mode

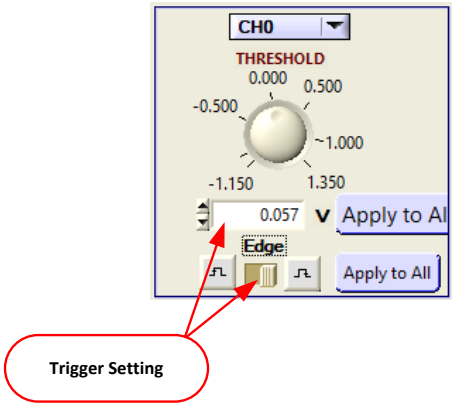
Next step is to tune the channel 0 DC offset and Trigger Threshold so that the board can trigger in self-trigger mode.

8. *DC Offset setting*: The *DC OFFSET* parameter in the VERTICAL tab must be set according to the polarity of the input signal to avoid saturations (p. **39**). Typically, positive *DC OFFSET* values are used with negative pulses, negative values with positive pulses, while *DC OFFSET* = 0 can be used with bipolar pulses (the baseline of the signal stabilizes around half the ADC dynamic).

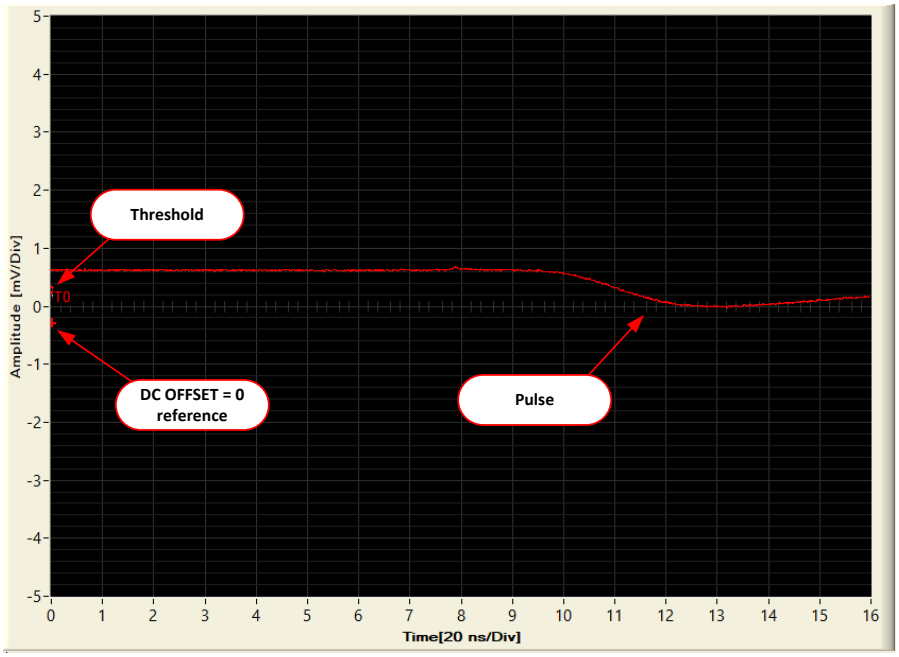


9. *Trigger Threshold setting*: Set a value for the Trigger Threshold in the TRIGGER tab (which refers to the *DC OFFSET* level) approximately around half the expected amplitude of the input signal.

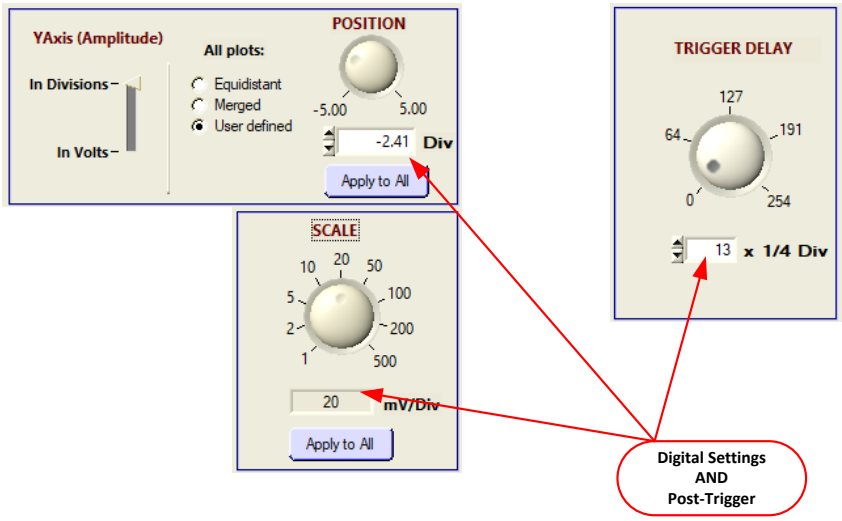
10. *Pulse Polarity setting*: Set the *Edge* parameter on "falling" symbol in case of negative pulses; the self-trigger will be issued when the input signal crosses the threshold on its falling edge.

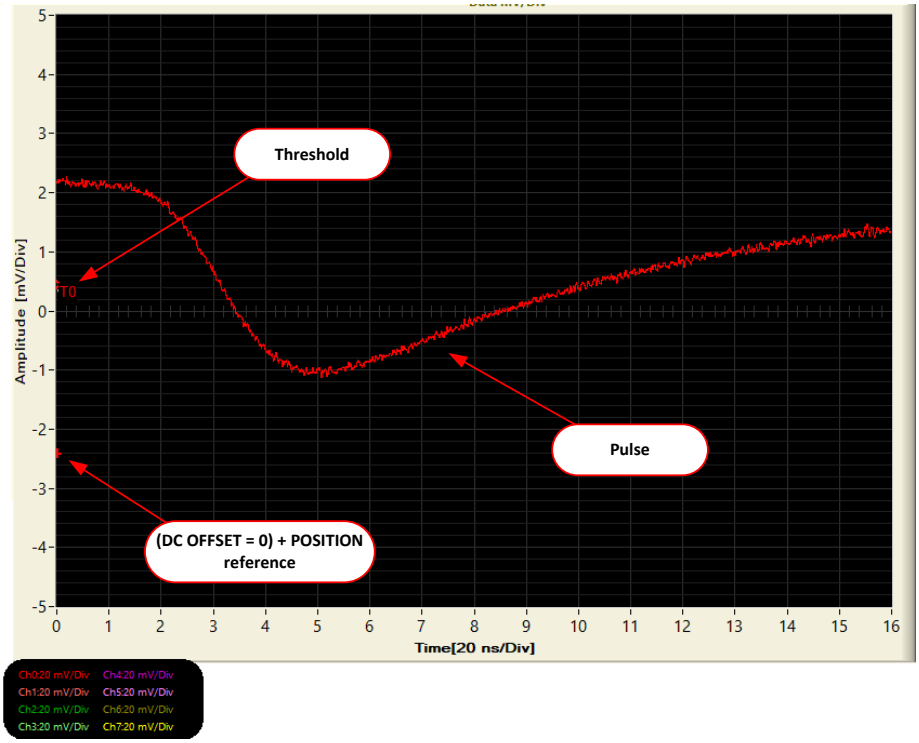


11. *Self-Trigger Mode setting*: Switch *TRIGGER TYPE* on *Normal* in the TRIGGER tab to enable the self-trigger mode; if the board does not continue to trigger (front panel RUN and TRG LEDs are on), then set a lower value for the Trigger Threshold and try again.



12. *Post-Trigger and Digital Settings*: Use the TRIGGER DELAY in the HORIZONTAL/ACQ tab to adjust the position of the trigger withing the acquisition window and the SCALE and POSITION settings in the VERTICAL tab and to possible apply a digital vertical zoom and offset to better fit the pulse to the Graph Display.

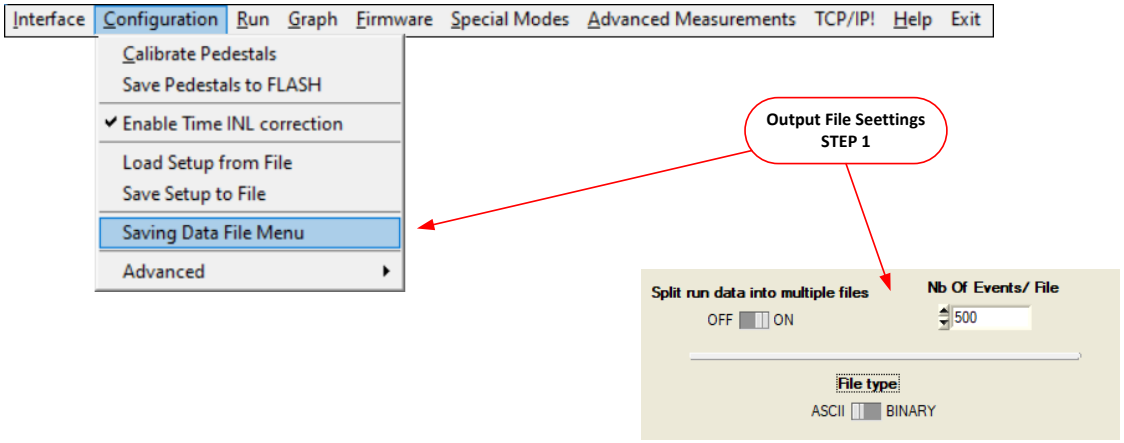




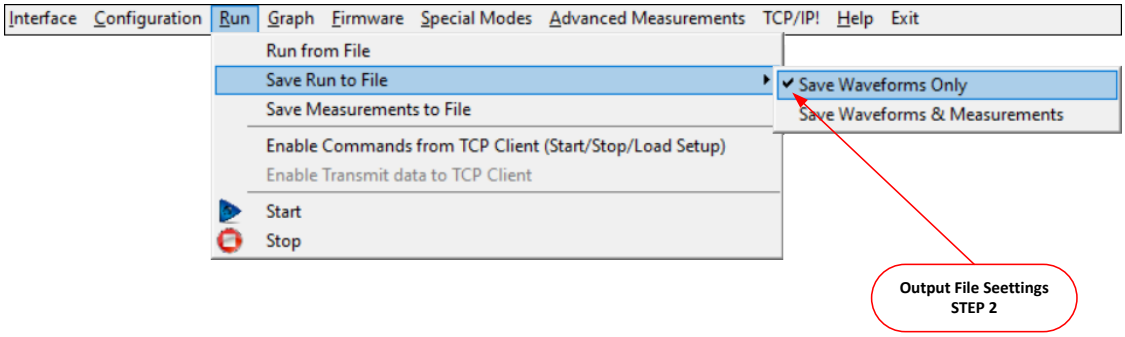
13.2.3Recording Waveforms

As a final step, suppose to set a waveform recording section based on the finite acquisition of 1000 events.

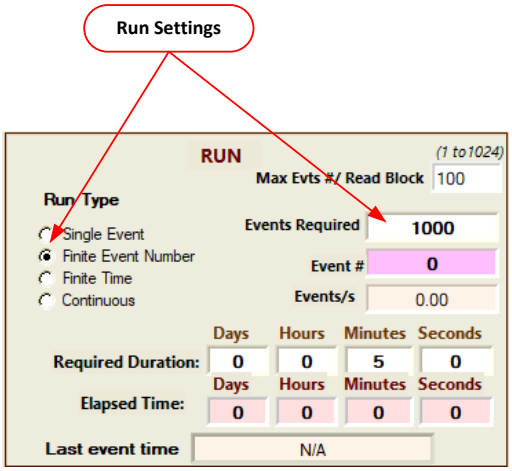
13. *Run Save Mode setting STEP 1*: Stop the current acquisition and open Save Data Menu in the Menu bar (Sec. **7.2.6**); select the ASCII format for the output files and to split the saved data into multiple files by 500 events each (two files will be generated in the end of the session).



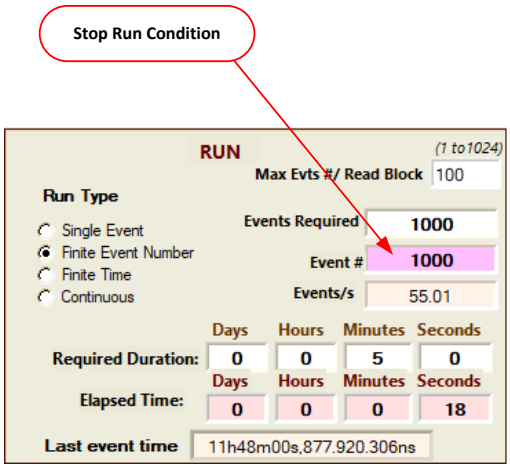
14. *Run Save Mode setting STEP 2*: Set Save Waveforms Only in the Menu bar (Sec. **7.3.2**)



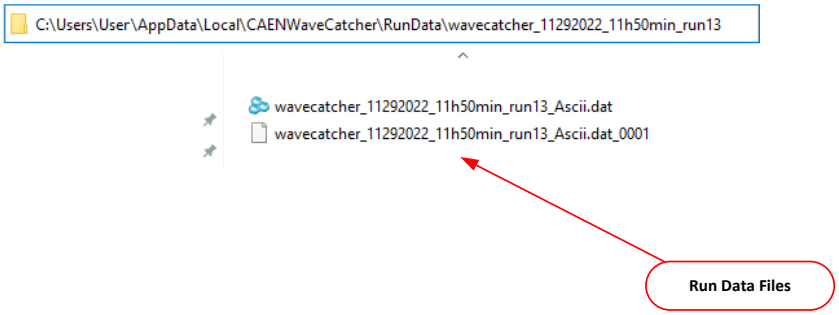
15. *Run settings:* Check the *Finite Event Number* option for the *RUN Type* in the Main tab and enter the number of events of the recording session (*Events Required*).



16. *Start recording:* Start the acquisition; the event counter (*Event#*) in the Main tab live updates the number of events being recorded. The acquisition automatically stops when the programmed event number is reached.



In the end, find the two output files (500 events each) saved in the destination path.

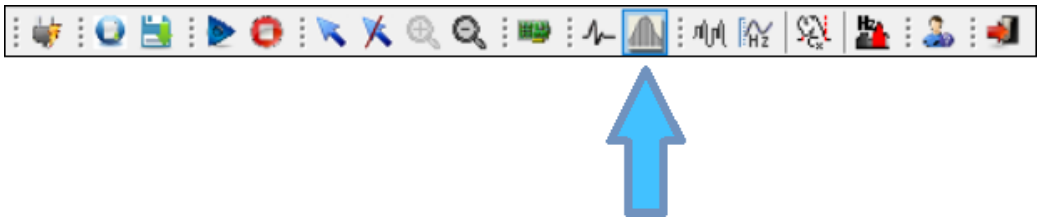


13.3 Charge Integration

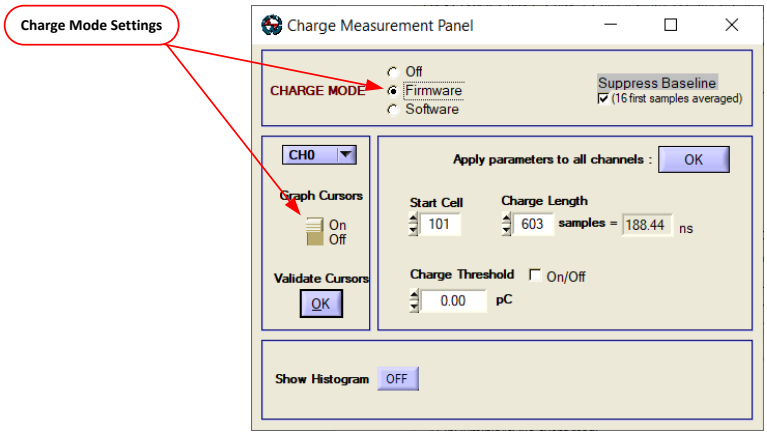
After getting familiar with the signal management, next step could be preparing for a charge integration session, taking advantage of the Charge Mode which is embedded in the digitizer firmware. WaveCatcher can manage the charge integration functions implemented in the digitizer firmware, but also the option to make the charge integration completely in the software (Sec. **7.6.2**).

13.3.1 Configuring the Charge Mode

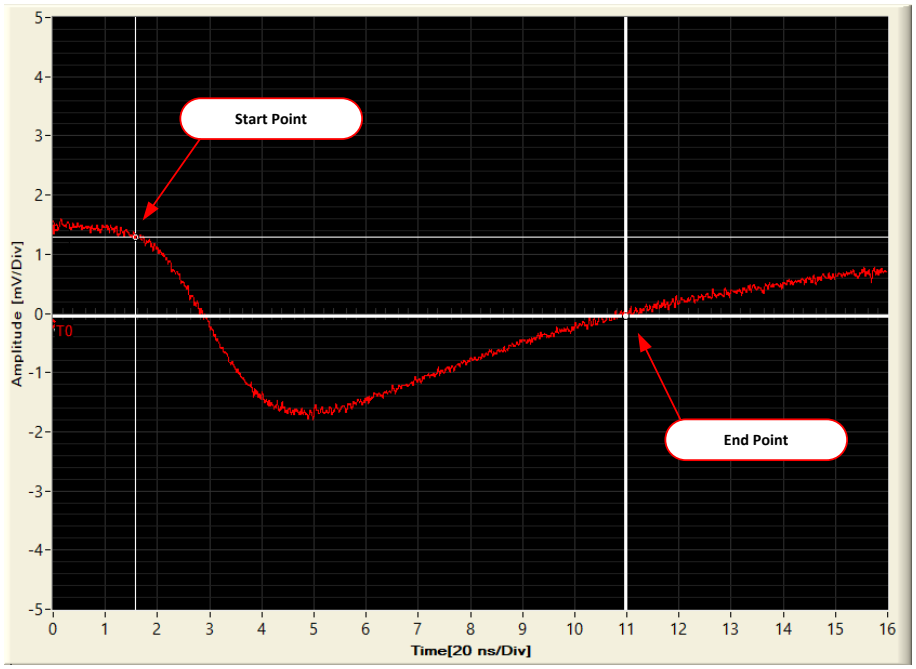
17. *Open the Charge Measurements panel*: Select the Charge Mode in the Icon bar.



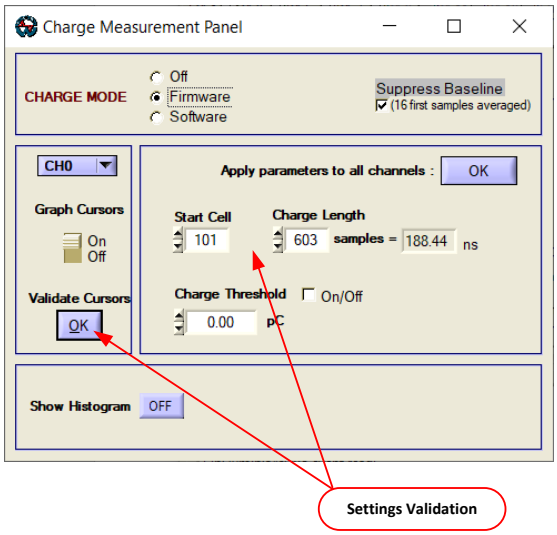
18. *Enable the Charge Mode and Cursors*: In the Charge Measurements panel, select the *Firmware* option for the *CHARGE MODE* function and enable the graphic cursors.



19. *Define the Charge Integration Window*: Place the cursors over the pulse in the plot to fix the starting and ending point of the desired integration interval.

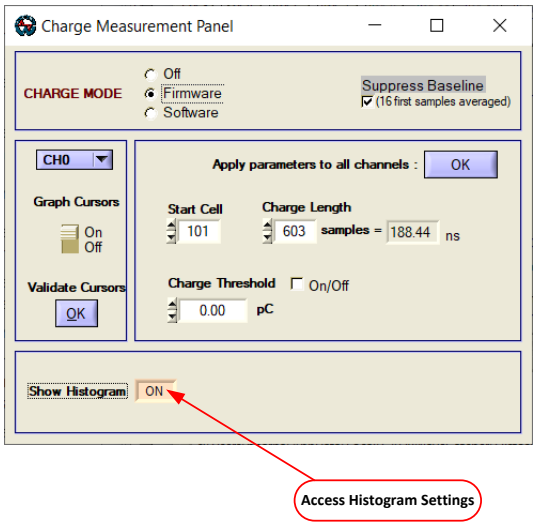


20. *Validate Settings*: Click on the *Validate Cursors* key to make the settings effective, the range information automatically updates in the panel (*Start Cell* and *Charge Length*).

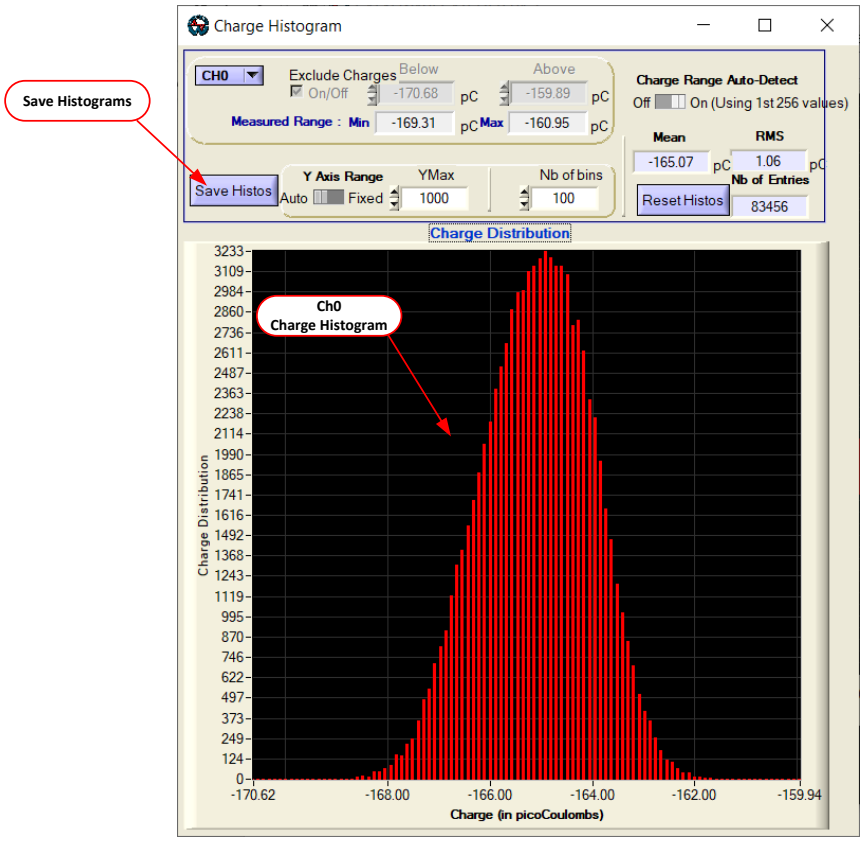


13.3.2Running in Charge Mode

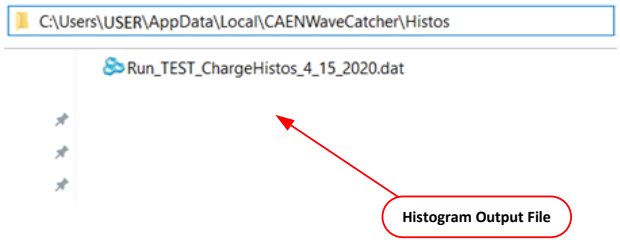
21. *Get Histograms*: Click on the *Show Histogram* key in the Charge Measurement panel; start the acquisition and the charge histogram is shown in the runtime plot. Default histogram settings can be changed in the same panel.



22. *Save Histograms to file*: Stop the acquisition as soon as enough statistics has been collected, then click on the *Save Histos* key to store the current charge histogram data for the only enabled channel 0 in an ASCII output file (Sec. **11.4**).



Customize the file name (e.g. *Run_TEST_ChargeHistos_4_15_2020.dat*) and find it stored in the destination path.



14 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:

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

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