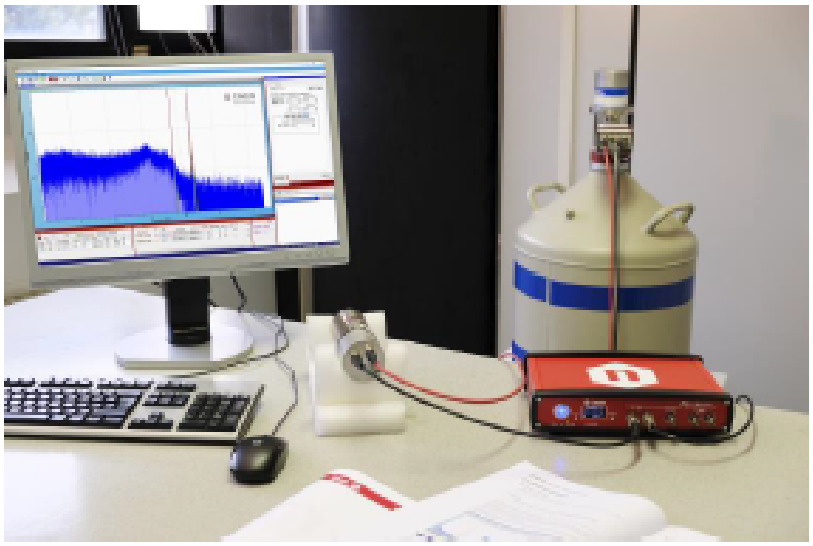
Rev. 3 - Sep 30th, 2023

Hexagon

Hexagon Quick Start Guide - Instructions for use



CAEN
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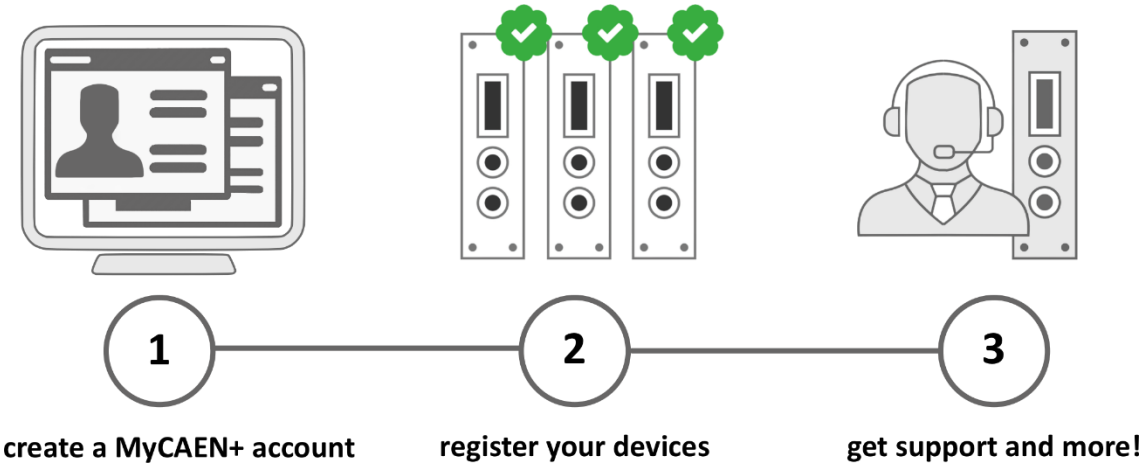
Guide
GD6505

Register your device

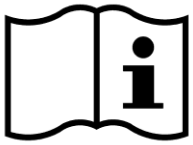
Register your device to your **MyCAEN+** account and get access to our customer services, such as notification for new firmware or software upgrade, tracking service procedures or open a ticket for assistance. **MyCAEN+** accounts have a dedicated support service for their registered products. A set of basic information can be shared with the operator, speeding up the troubleshooting process and improving the efficiency of the support interactions.

MyCAEN+ dashboard is designed to offer you a direct access to all our after sales services. Registration is totally free, to create an account go to https://www.caen.it/become-mycaenplus-user and fill the registration form with your data.



https://www.caen.it/become-mycaenplus-user/

Purpose of this Guide



The guide wants to provide all the information and instructions to start using the DT5000 – Hexagon Digital MCA and DT5001M – HexagonOne Digital MCA in a correct and easy way. The guide is compliant with Hexagon firmware release **0.99.22** and MC2Analyzer software release **2.1.12**. For future release compatibility check the firmware and software revision history files.

Change Document Record

Date	Revision	Changes
Aug 25th, 2018	00	Initial release
Feb 06th, 2020	01	Modified **HV Management** section
Oct 20th, 2021	02	Modified **Connecting to Hexagon** section
Sep 30th, 2023	03	Added **Register your device** Section. Modified First Page, Last Page, **Technical Support** Chapter

Symbols, abbreviated terms and notation

ADC	Analog to Digital Converter
CPU	Central Processing Unit
CSP	Charge Sensitive Preamplifier
DPP	Digital Pulse Processing
DPP-PHA	DPP for Pulse Height Analysis
FTP	Foiled Twisted Pair
HPGe	High Purity Germanium
HVPS	High Voltage Power Supply
MCA	Multi-Channel Analyzer
OLED	Organic Light Emitting Diode
OS	Operating System
OTG	On-The-Go
PHA	Pulse Height Analysis
TRP	Transistor Reset Preamplifier

Reference Documents

[RD1] UM3182 - DPP-PHA and MC^{2}Analyzer User Manual

[RD2] DS6511 – DT5000 – Hexagon Digital MCA Datasheet

https://www.caen.it/support-services/documentation-area/

Manufacturer Contacts

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Limitation of Responsibility

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

Disclaimer

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

Made in Italy

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

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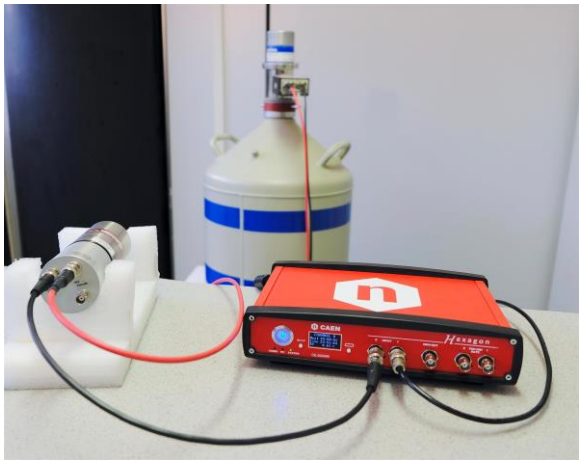
1 Introduction

Hexagon is a 32K dual input digital MCA suited for digital Nuclear Spectroscopy.

The module is designed to be used with high energy resolution semiconductor detectors like HPGe, but also with NaI and LaBr3 scintillators connected to a CSP or directly from a PMT.

The compact desktop form factor integrates:

- 2 analog inputs with the analog front-end for the signal conditioning each of them featutering:
  - a 16-bit and 100 MHz Flash ADC;
  - FPGA with advanced firmware algorithms and programmable parameters operating Digital Pulse Processing for the Pulse Height Analysis (DPP-PHA);
- 2 Preamp power supply rails (±12V, ±24V) on DB9 connector for TRP and resistive preamplifier with TRP inhibit on dedicated BNC connector;
- 2 HV output channels (dual range) for detector power supply with HV inhibit on dedicated BNC and DB9 connectors. The board can be equipped with either 2 positive HV channels, or 2 negatives, or the mixed option by ordering code (see **Tab. 1.1**).



Note: An Hexagon version with one input channel only (HexagonOne) is also available.

Hexagon can operate either in PHA mode, providing energy histograms, or in Oscilloscope mode, where analog inputs and digital outputs from the internal filters are available for debug and monitoring, or time-stamped List mode.

Thanks to the simultaneous acquisition on two inputs, Hexagon is suitable for coincidence and anti-coincidence logic between detectors, eg Anti-Compton Shield.

The embedded CPU runs an OS able to execute custom routines for automated operations.

The module is equipped with a OLED display to monitor in real time the data acquisition parameters and status like ICR, OCR and dead time.

The communication with Hexagon is possible through USB (2.0) and ETHERNET (10/100T) interfaces.

Hexagon is fully supported by CAEN MC^2 Analyzer software on Windows®.

This Quick Start Guide contains an example of application of the dual Multichannel Analyzer Hexagon together with the MC^2 Analyzer software and will guide the user to step by step setting the most important acquisition parameters, acquiring spectra and save the data.

Board Model	Description	Product Code
DT5000P	Hexagon Dual Digital MCA - Positive HV	WDT5000XPAAA
DT5000N	Hexagon Dual Digital MCA - Negative HV	WDT5000XNAAA
DT5000M	Hexagon Dual Digital MCA - Mixed HV	WDT5000XMAAA
DT5001M	HexagonOne Digital MCA – Mixed HV	WDT5001XMAAA

Tab. 1.1: Products table

2 Technical Specifications

MECHANICAL	**Enclosure** Metal with hard rubber supports. **Dimensions** ▪ 262 W x 66.2 H x 195 L mm³ (including connectors) ▪ 262 W x 66.2 H x 171.6 L mm³ (without connectors)	Weight 1400 g.
INPUTS	**INPUT 0 and 1 (front panel)** Analog signal input connector, BNC type, 500 Ω input impedance, AC or DC coupled. Accepts positive or negative input signals from Detectors, Resistive Feedback or Transistor Reset associated preamplifiers. Input range of 1 V_{pp} divided by the selectable gain, 4 V_{pp} with x0.25 attenuation, 2V_{pp} with x0.5 attenuation. **DC POWER IN (rear panel)** ▪ 12V DC power jack, mechanically lockable ▪ I_{max}: 2.5 A ▪ AC Adaptor (12V, 3.75A) included	**TRP INH / GATE 0 and 1 (front panel)** Input connector, BNC type, TTL/NIM, software selectable function: ▪ Reset of the Transistor Reset Preamplifier ▪ Gate signal for coincidence/anticoincidence **HV INH 0 and 1 (rear panel)** HVPS inhibit connector, BNC type, software selectable positive or negative polarity (positive by default). Inhibit function also available on the rear DB9 connector.
OUTPUTS	**HV 0 and 1 (rear panel)** HVPS output connector, SHV type; dual range, software selectable: 2kV/1mA or 5kV/30µA; ripple < 5 mV_{pp}. HV channel polarity, both positive, both negative, mixed is by ordering code (see **Tab. 1.1**). **PREAMP 0 and 1 (rear panel)** Preamp power connector, 9-pin D-connector. Provides ±12 V (± 2%), ±24 V (± 2%) and ground for standard preamplifiers; ripple < 5 mV_{pp}. – +12 V @ 100 mA – -12 V @ 100 mA – +24 V @ 50 mA – - 24 V @ 50 mA Includes: – 0 ÷ 10 V auxiliary voltage input – PT100 and PT1000 resistance thermometers compliant input for detector temperature readout – HVPS external inhibit input (also available on BNC connector).	**MON-OUT (front panel)** Analog output. Provides a selection of internal analog probes: – A copy of the input signal (4 V_{pp} FSR) – The Fast Trigger – The Trapezoid – The Trapezoid-Baseline Software selectable.
COMMUNICATION INTERFACES	**USB (rear panel)** USB2.0 connector, type miniUSB. Allows for direct USB connection to a PC or host station. USB cable included in the kit.	**10/100T (rear panel)** Ethernet connector, type RJ45. Supports 10, 100 Mbit/s connection to a PC or ETH hub. FTP cable included in the kit.
SYNCHRONIZATION	**SYNC IN (rear panel)** Input connector, type SATA. Used as time stamp reset and list marker. Allows for the clock Daisy chain of multiple boards in combination with SYNC OUT.	**SYNC OUT (rear panel)** Output connector for multi-board synchronization, type SATA. Allows for the clock Daisy chain of multiple boards in combination with SYNC IN.
I/Os	**GPIO (rear panel)** DB25 connector featuring inputs and outputs for dedicated functions: **Inputs (LVTTL, Z_{in} 1kΩ)** Trigger Time Stamp Reset (at least 100 ns)	**Outputs (LVTTL, do not require 50 Ω termination)** ICR

DIAGNOSTICS LEDs	**COMM (front panel)** Communication LED, colour green. It is on when there is activity on the USB or the ETHERNET channel. **STATUS (front panel)** Status LED, bi-colour red/green. ▪ Continuous green: the board is ready to start ▪ Blinking green: the board is in RUN state ▪ Continuous red: the board is in BUSY state **HV (front panel)** HVPS LED, red colour. It is on when there is a HV fail. **INPUT LED 0 and 1 (front panel)** Trigger LED, colour green. It is on when a trigger is generated on the relevant analog input channel. **TRP-INH/GATE LED 0 and 1 (front panel)** Transistor Reset Preamplifier channel Inhibit LED, colour green. It is on when the inhibit is active on the relevant TRP input channel.	**HVPS LEDs (rear panel)** ▪ **INH:** channel inhibit LED, colour green. It is on when inhibit is active ▪ **OVC:** channel over-current LED, colour red. It is on if the channel tries to draw more current than the programmed limit ▪ **ON:** channel enable LED, colour red. It is on when the HVPS channel is active ▪ **POS:** positive polarity LED, colour green. It is on in case of positive HVPS channel ▪ **NEG:** negative polarity LED, colour yellow. It is on in case of negative HVPS channel **SYNC** Synchronization LED, colour green. It is on when the board clock is locked to CLOCK IN.
ACTIVE BUTTONS	**POWER (front panel)** Power on/off button. Blue illuminated when the power is on.	**RESET (rear panel)** Holding this button pressed for 3 seconds causes a global reset of the board (HVPS channels ramp-down and board reset).
MONITORING DISPLAY	**GRAPHIC DISPLAY (front panel)** Monochrome 1.3" OLED display only for monitoring usage. **Screen 1:** Time acquisition data ▪ Live Time (hh mm ss) ▪ Real Time (hh mm ss) ▪ Dead Time (%) **Screen 2:** Readout data ▪ ICR (Hz, kHz, MHz) ▪ OCR (Hz, kHz, MHz) ▪ Dead Time (%) **Screen 3:** HVPS data ▪ V_{mon} / V_{set} (V) ▪ I_{mon} (µA)	**BROWSE BUTTONS (front panel)** ▪ **Channel select (0<--->1):** switches between the two analog input channels (if Screen1 and Screen 2) or the two HPVS channels (if Screen 3) ▪ **Screen select:** switches amongst the different screens
ADC	**RESOLUTION** 16 bits	**SAMPLING RATE** 100 MHz
CONFIGURABLE CONTROLS (by SW)	**ANALOG INPUT SETTINGS** ▪ **Coarse Gain:** x1, x2, x4, x8, x16, x32, x64, x128, x256 ▪ **Gain Attenuation:** x0.25, x0.5 ▪ **DC Offset:** adjustable in the whole input range **ACQUISITION MODES** ▪ **Oscilloscope:** analog and digital signals can be inspected and plotted. ▪ **PHA:** setting the digital pulse processing programmable parameters, energy histograms are built up by the board and can be plotted and saved to file ▪ **List:** raw energy and time tag data are provided and can be saved to file. ▪ **Coincidence/anticoincidence:** allows for single channel mode (uncorrelated), board coincidence/anticoincidence between channel 0 and channel 1, external coincidence (GATE) and external anticoincidence (INHIBIT)	**DIGITAL FILTERS** ▪ **Fine Gain:** from 0.8 up to 2.2 with steps of 0.001 ▪ **Trapezoid filter** for energy calculation ▪ **Rise Time:** 40.95 µs max. ▪ **Flat Top:** 20.47 µs max. ▪ **Manual trapezoid pole / zero compensation** ▪ **Manual AC-coupled input signal pole / zero compensation** ▪ **Baseline restorer with programmable averaging** ▪ **Fast Discriminator** for time tagging and ICR ▪ **Time Tag resolution:** 10 ns, 62 bit and roll-over tracking event ▪ **Manual fast discriminator threshold adjustment** ▪ **Pile-up rejection and live time correction** ▪ **Histogram rebinning** (PHA mode)
FIRMWARE	Firmware can be upgraded via USB/ETHERNET	
SOFTWARE	Fully controlled by the MC² Analyzer spectroscopy software on Windows® (rel. 2.0.0 or higher). For developers, general purpose DPP library is available with source code and examples (Linux® and Windows® compatibility); possibility to develop the software through the PC directly on the board.	

Tab. 2.1: Hexagon specifications table

3 System Components

The Hexagon kit is composed of the following items:

Hexagon DT5000 Digital MCA

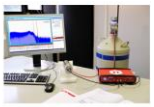
45W 12V Single Output AC-DC Adaptor

Power Supply Cable

1MT USB OTG Shielded I/O Cable

Type A-to-miniUSB

2MT Cat6 S-FTP Ethernet Cable



User Guide

Note: Download the User Manual of the MC^2 Analyzer from CAEN website for the full description of the DPP-PHA firmware running on Hexagon **[RD1]**.

4 Getting Started

Hardware Setup

The example described in this guide is a typical application of Hexagon MCA and MC²Analyzer software for the characterization of HPGe detectors response in a measurement of resolution of the ^{60}Co source photo-peaks.

The high and low voltages are provided by Hexagon, which integrates in a single unit both the high voltage power supply, the low voltage, and the readout channels. A scheme of the hardware setup is shown on

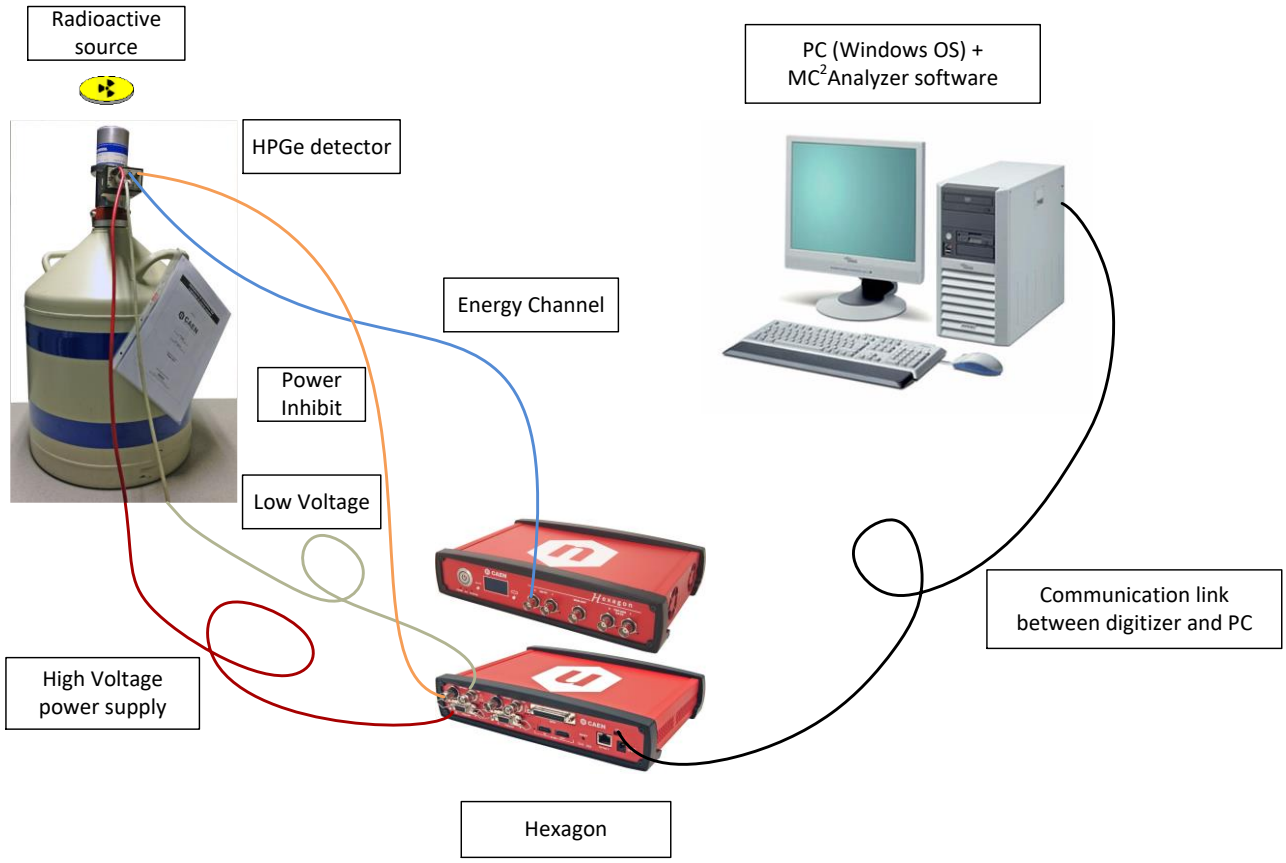


Fig. 4.1: Typical setup for resolution measurements using HPGe detectors and the Hexagon Digital MCA

Hexagon Installation and Power-on

- Connect the AC/DC Adaptor to the DC power jack
- Push the Power button, which must turn on blue
- The Comm and Status LEDs blink until the system is ready to start, then the Status LED remains on (the Output Buffer is cleared, and the registers are set to the latest configuration settings)
- The OLED display shows the splash screen, then switches on Screen 1 (see Chap. **2**).

Fig. 4.2: Hexagon power-on status

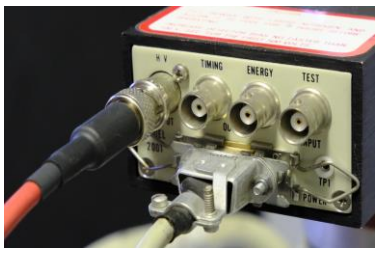
Power-off

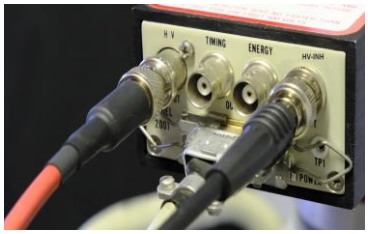
To power off Hexagon, just push the Power button.

> ***WARNING:***
>
> ***TO PREVENT POSSIBLE DAMAGES TO THE ATTACHED DETECTOR AND ELECTRONICS, MAKE SURE TO TURN OFF THE HV CHANNELS BEFORE TO POWER OFF THE BOARD!!!***

Connections Overview

Tab. 4.1 shows the standard connections between Hexagon and a HPGe detector mounting a CSP.

HEXAGON		PREAMP	
	SHV cable connection on the MCA side		SHV cable connection on the PREAMP side
	PREAMP cable connection on the MCA side		PREAMP cable connection on the PREAMP side
	HV-INHIBIT		HV-INHIBIT

	cable connection on the MCA side		cable connection on the PREAMP side
	ENERGY cable connection on the MCA side		ENERGY cable connection on the PREAMP side

Tab. 4.1: Table of connections

Software Setup

USB Link

When connecting Hexagon to a PC by the USB link for the first time, the miniUSB driver will be automatically installed. The device will be recognized under the "Device Manager" window among "Network adapters".

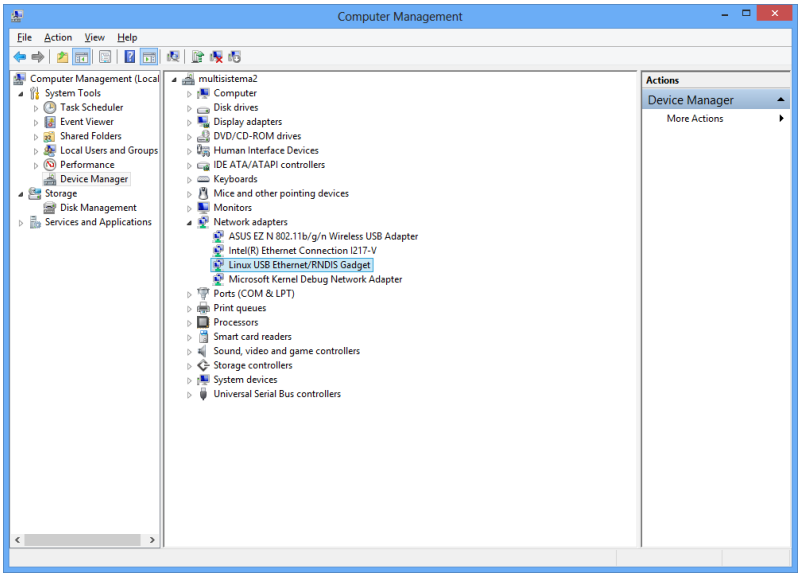


Fig. 4.3: The USB connection to Hexagon is recognized as a virtual Ethernet connection

The device will be recognized also as an external storage unit in which the MC^2 Analyzer installer, the MC^2 Analyzer full manual and this Guide are included.

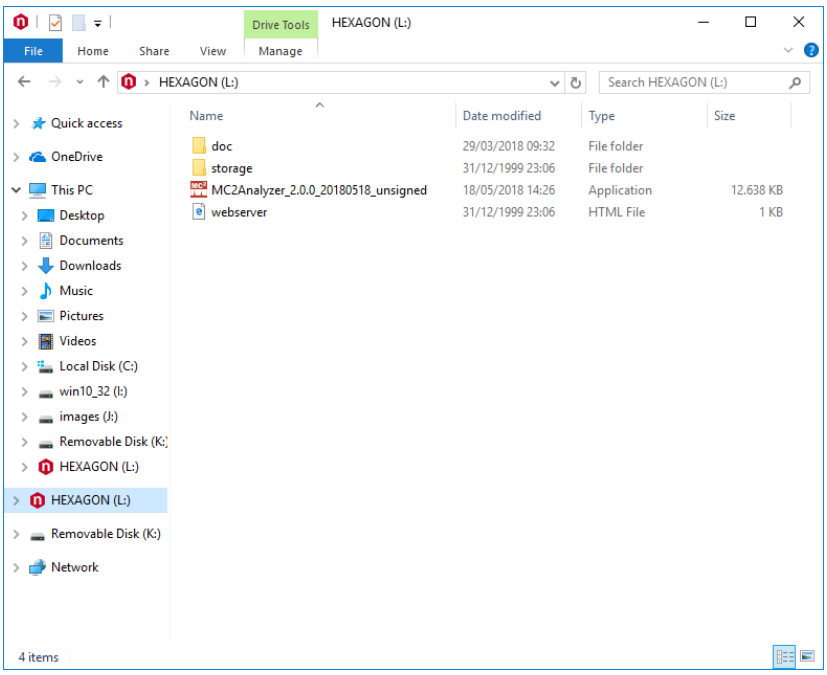


Fig. 4.4: The USB connection to Hexagon is recognized as an external storage unit

Network Configuration

Hexagon supports also the Ethernet communication interface. The connection can be done through a server, or it can be a point-to-point connection to the PC. In the latter case, the connection can be done using a crossed cable, a switch, or a computer with a Gigabit Ethernet port. Connect the Ethernet cable from the MCA to the computer and configure the network according to the instructions below.

Note: The default IP Address of Hexagon is: **172.16.0.2**

1. Open the path:

`Control Panel - Network and Internet - Network and Sharing Center`

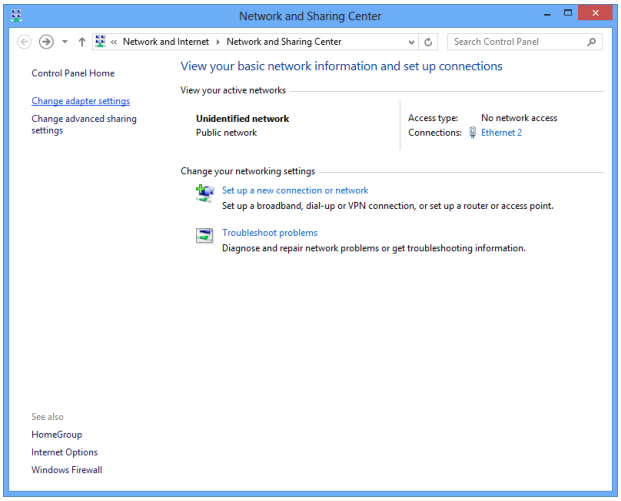


Fig. 4.5: Network and Sharing Center window

2. Click on “Change adapter settings”.

3. Right click on the Ethernet icon and select “Properties” (see **Fig. 4.6**)

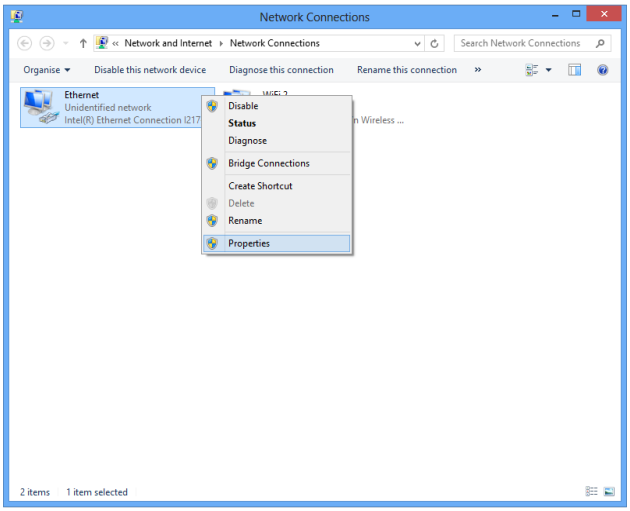


Fig. 4.6: Network Connections window

4. Click on “Internet Protocol Version (TPC/IPv4)”, and select “Properties” (see Fig. 4.7)

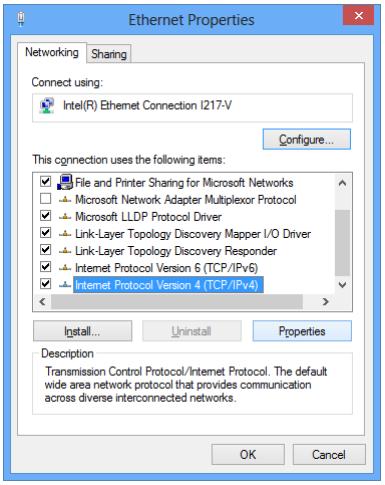


Fig. 4.7: Ethernet Properties window

5. Copy the same configuration as in **Fig. 4.8** on the “Internet Protocol Version (TPC/IPv4) Properties” window.

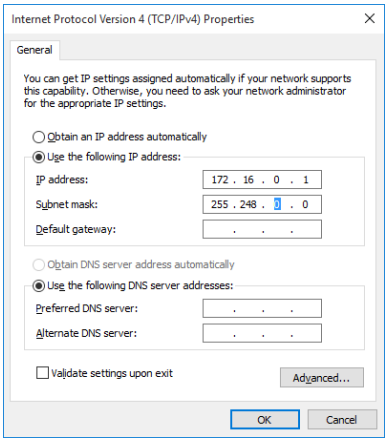


Fig. 4.8: Internet Protocol Version 4 (TCP/IPv4) Properties window

Software Installation

> ***Hexagon is fully supported by the MC²Analyzer software for Windows® OS, starting from release 2.0.0 on (Linux® is currently not supported).***

MC² Analyzer requires the third-party software .NET Framework 4.0 or later, downloadable from Microsoft© website.

- Make sure that Hexagon hardware is properly installed (refer to Sect. **Hexagon Installation and Power-on**).
- Make sure that Hexagon is properly recognized in case of USB connection or the Network Configuration is properly set in case of Ethernet connection (see Sect. **Software Setup**).

CAEN provides the full installation package for the MC²Analyzer Software in a standalone version which installs all the binary files and required libraries.

1. Download the MC²Analyzer Software from CAEN Website under the path:

   Home / Products / Firmware/Software / Digitizer Software / Readout Software / MC2 Analyzer

2. Extract the files and run the executable “MC2Analyzer_x.x.x.exe”.
3. The CAEN MC²Analyzer Setup Wizard will guide you throughout the installation procedure.

Note: the following screenshot are taken with Window 7 OS, and they can be generalized for Windows 8 and Windows 10.

Fig. 4.9: MC²Analyzer Wizard Dialog Box- Start Installation

Left click on “Next” (or left click on “Cancel” any time during the installation process to abort the installation).

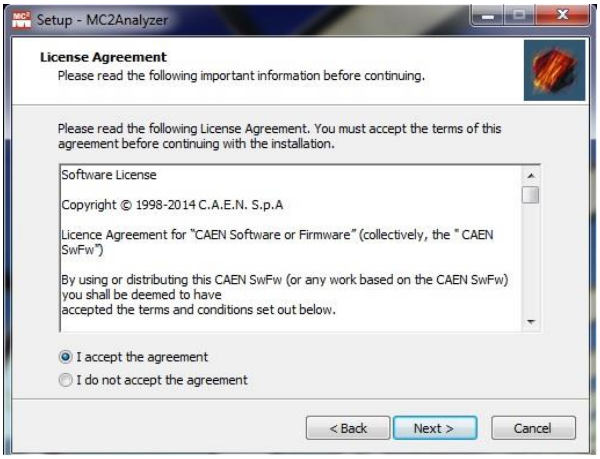


Fig. 4.10: MC²Analyzer Wizard Dialog Box - License Agreement

Please, read the MC²Analyzer Software License Agreement and select “I accept the agreement” to continue the installation. Left click on “Next” (or left click on “Back” at any time during the installation process to modify the previous settings).

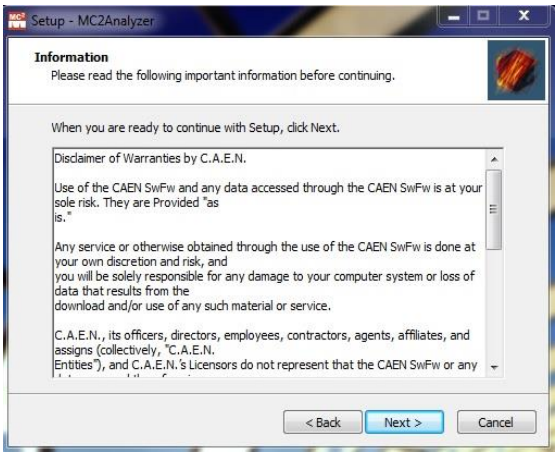


Fig. 4.11: MC2Analyzer Wizard Dialog Box - Disclaimer

Please, read the CAEN Disclaimer information then left click on “Next” to continue.

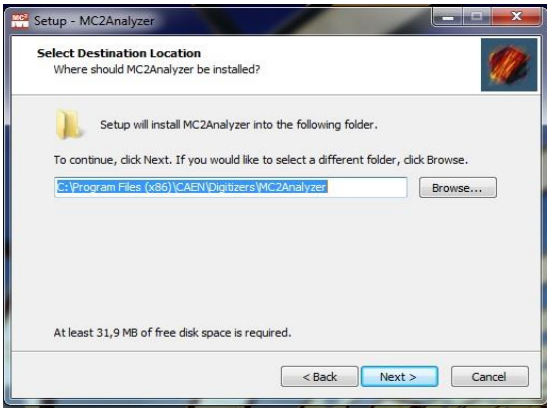


Fig. 4.12: MC2Analyzer Wizard Dialog Box – Installation Folder Selection

To install the MC²Analyzer Software, a minimum free space of about 32 MB of free Hard Disk space is required. Select a folder for the installation of the CAEN MC²Analyzer Software by using the “Browser” button or by typing the desired path in the white entry box. The default path is:

C:\Program Files\CAEN\Digitizers\MC2Analyzer (Windows 32 bit)

or

C:\Program Files (x86)\CAEN\Digitizers\MC2Analyzer (Windows 64 bit).

Left click on “Next” to continue.

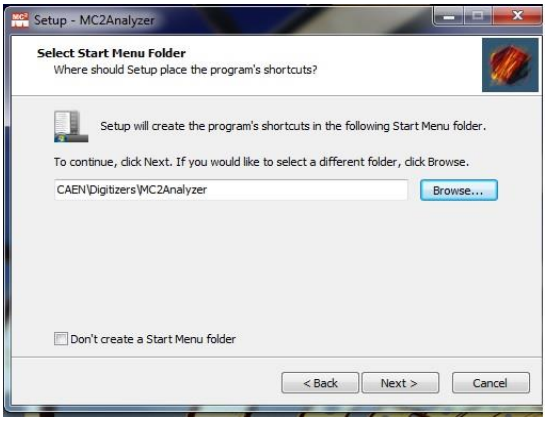


Fig. 4.13: MC²Analyzer Wizard Dialog Box – Shortcuts

Optionally, select a Start Menu folder for the installation of the CAEN MC²Analyzer Software Shortcuts by using the "Browser" button or by typing the desired path in the white entry box. The default path is: *C:\Program Files\CAEN\Digitizers\MC2Analyzer* (Windows 32 bit) or *C:\Program Files (x86)\CAEN\Digitizers\MC2Analyzer* (Windows 64 bit). If you do not wish to create a Start Menu folder mark the checkbox labelled "Don't create a Start Menu folder".

Left click on "Next" to continue.

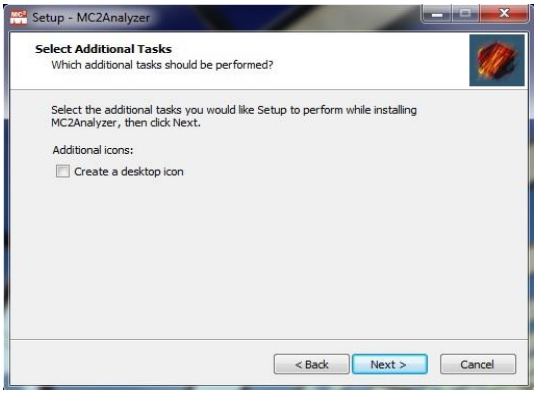


Fig. 4.14: MC2Analyzer Wizard Dialog Box – Desktop Icon Selection

Optionally, mark the checkbox labelled "Create a desktop icon" to create an MC²Analyzer icon on your computer Desktop.

Left click on "Next" to continue.

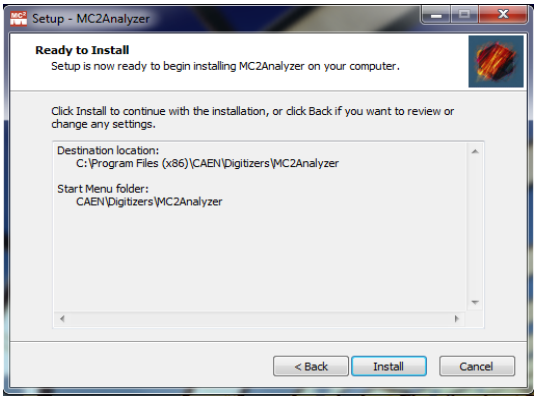


Fig. 4.15: MC2Analyzer Wizard Dialog Box – Installation

Please, revise the MC²Analyzer Program Destination path and the Start Menu folder you have selected, if any.

Left click on "Install" to install the CAEN MC²Analyzer Software.

The CAEN MC²Analyzer Setup Wizard will extract and install the relevant files. At the end of the installation, the Dialog Box as in **Fig. 4.16** will appear.

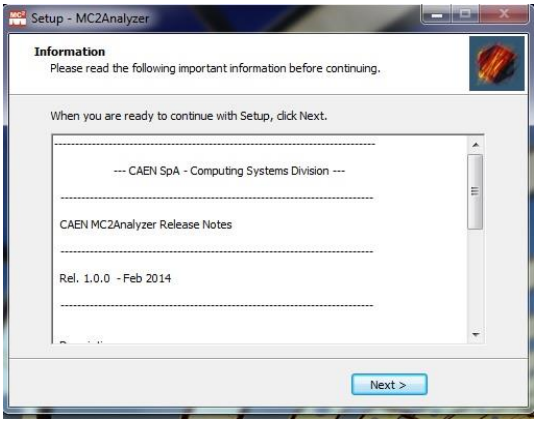


Fig. 4.16: MC2Analyzer Wizard Dialog Box – Software Release Version Notes

Please, read the Release Notes of the MC²Analyzer Software before continuing. This document is updated for every official release of MC²Analyzer and it contains various updated information specific to this software which may not be found in the User's Manual, available together with the software or on the CAEN web site: www.caen.it.

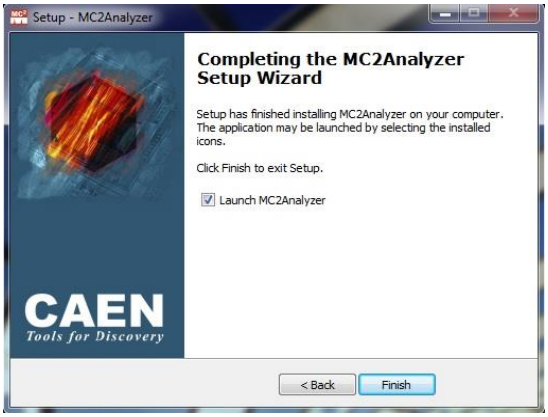


Fig. 4.17: MC2Analyzer Wizard Dialog Box – Finish Installation

To complete the MC²Analyzer Installation, left click on “Finish”. The MC²Analyzer Program can be launched by marking the check box “Launch MC2Analyzer Analyzer” before finishing the installation, or by left clicking on the installed icons in the Start Menu Folder.

Connecting to Hexagon

According to the preferred communication interface, it is possible to connect to the MC²Analyzer software via Mini USB or Ethernet.

Note: The software requires an active rule in the firewall. Click "Allow**"** to permit the MC²Analyzer connection.

From the main panel of the MC²Analyzer software GUI, select:

FILE -> Add Spectrum

or press the button .

The window as in **Fig. 4.18** will appear.

Select "Online Spectrum" and "New Board Connection" to connect the software to the digital MCA.

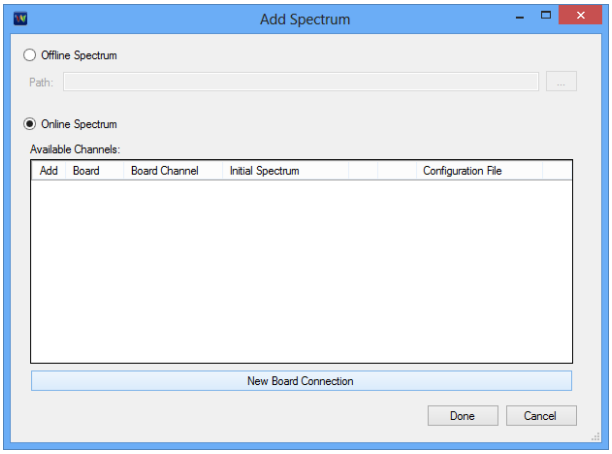


Fig. 4.18: the "Add Spectrum" window to add an offline spectrum from file or an online spectrum from board

Mini USB interface

In the Device Connection window (see **Fig. 4.19**), select Connection = MiniUSB and write the device serial number S/N, which is available on the bottom panel of the and Hexagon. Press Connect when ready.

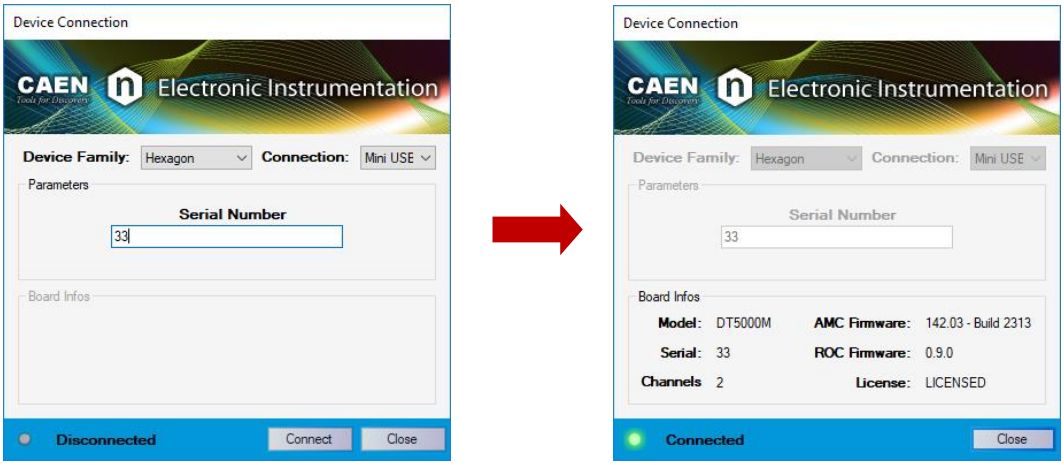


Fig. 4.19: Connection parameters in case of mini USB connection

Note: In case of Hexagon tagged with a PID number instead of S/N the user has to write on the Serial Number field not the PID number but the whole Hexagon IP address. The latter can be retrieved:

1. accessing the Hexagon Web Interface, from the browser address bar, eg http://172.24.1.134/.
2. Pressing the Hexagon front panel right white button unit the NET address page appears

Ethernet interface

In the Device Connection window (see **Fig. 4.20**), select Connection = Ethernet, and write the device IP Address = 172.16.0.2. Press Connect when ready.

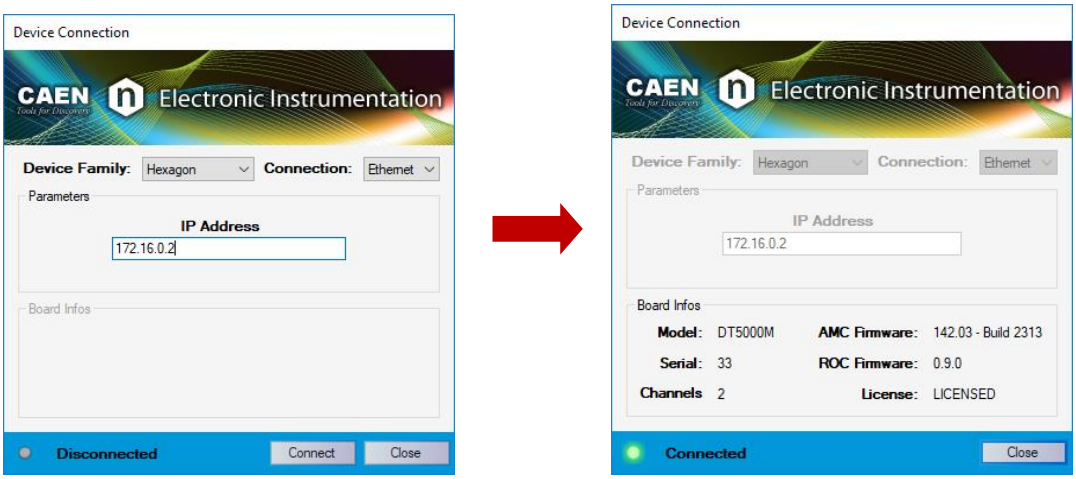


Fig. 4.20: Connection parameters in case of Ethernet connection

Channel Selection and Default GUI Layout

From the “Add Spectrum” window, select the channels for the acquisition (see **Fig. 4.21**).

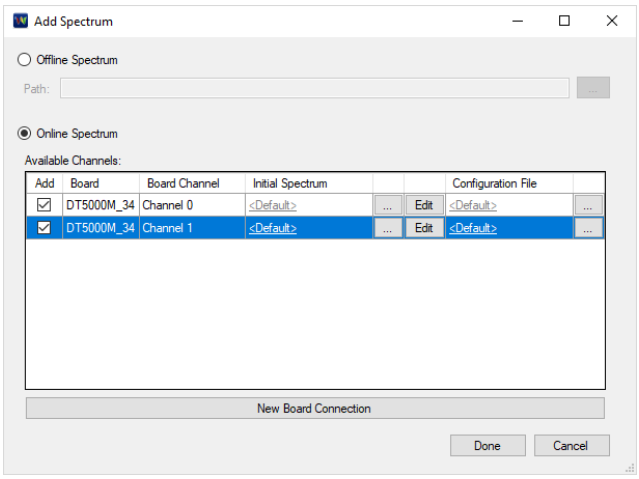


Fig. 4.21: Add Spectrum window allows to select the desired board channels for the acquisition

The default GUI interface will be then available (see **Fig. 4.22**).

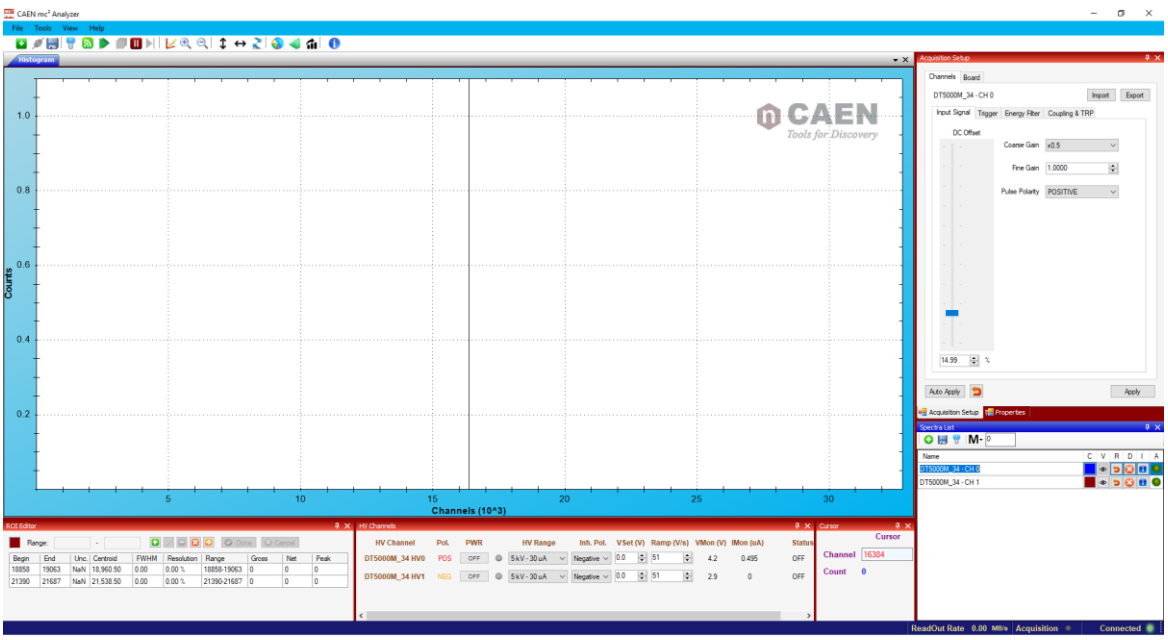


Fig. 4.22: The default GUI at the first connection

With Hexagon, the MC²Analyzer software restores the latest configuration and adds the channels previously added. If the user wants to add the second channel, the “Add Spectrum” window must be used.

HV Management

Open the “HV Channels” window.

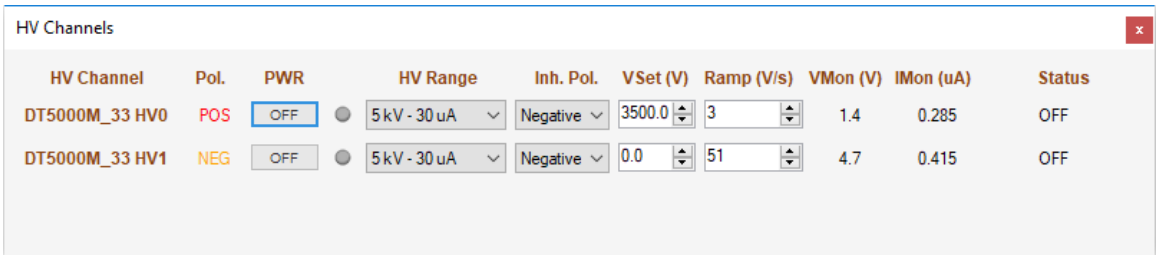


Fig. 4.23: “HV Channels” window for the setting and monitoring of the HV channels of Hexagon

Set the desired **HV Range**.

Set the required Inhibit Polarity (**Inh. Pol.**) according to the detector specifications.

Set the desired High Voltage value **VSET** according to your detector specifications.

Select the proper value for the Ramp corresponding to the value of V/sec of voltage ramp.

Press ON when ready, and check the HV status from the **VMON**, **IMON** and **STATUS** flags.

Besides the “5kV – 30 uA” (HPGe) and the “2kV – 1mA” (PMT) modes, Hexagon feature a “500V – 50 uA” (Silicon) mode. In order to select this mode, the user has to do the following procedure:

1. Press together the two white buttons near the LED screen and power on Hexagon. Hexagon enters in the RECOVERY mode;
2. Using the right button scroll down to HV SET. Press the left button to enter.
3. Using the right button scroll down to select which of the channels has to be set in the Silicon mode. Press the left button to enter.
4. Select SDD and press the left button to confirm to enter the Silicon mode or select H+P and press the left button to confirm to enter the HPGe/PMT mode

A "click" from the board means that the selected mode is properly set.

When operating in Silicon detector mode, MC2 Analyzer allows the user to set the desired **VSET** but to move to the HPGe or PMT mode anymore.

Note: The HV remains ON even if the user disconnects the software from the digitizer. When connected again the software automatically reloads the last HV settings.

Note: In case Hexagon remains stuck and the communication between the software and the MCA is no longer possible, it is possible to power off the HV pressing the **RESET** button on the rear panel of the module for 3 seconds.

Before Starting the Acquisition

It is very important to check the preamplifier output in an oscilloscope device before feeding the pre-amplified signal into the digitizer input.

The user must check:

- the signal polarity;
- that the preamplifier output dynamics is not saturated;
- approximately the dynamic range of the input signal in order to choose the proper coarse gain value

In the unlikely event one of the above conditions is found, the user must take care of the proper work around.

Channel Settings

The correct configuration of the channel settings allows to reach very precise resolutions in spectroscopy measurement. For this reason, a proper setting is very important. This section will guide the user throughout the settings configuration. The first step is to enable the "Signal Inspector" window to check the effects of the setting modifications on the digital filters.

Open the Signal Inspector Window

To open the "Signal Inspector" window, press the button  in the icon bar.

Look at the displayed note, then press "Continue" (see **Fig. 4.24**).

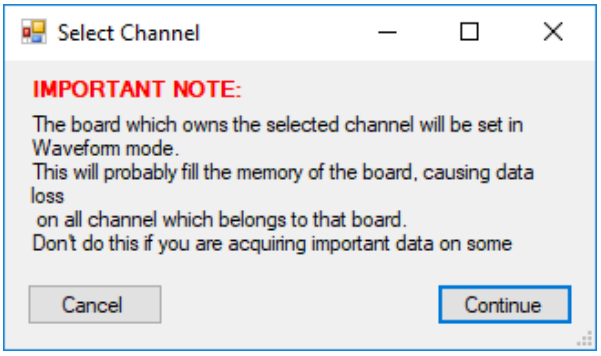


Fig. 4.24: "Select Channel" window note

It is possible to visualize a set of analog and digital traces.

A good starting point is to visualize:

- "Input" as "Analog Trace 1"
- "Trapezoid-Baseline" as "Analog Trace 2"
- "Peaking" as "Digital Trace 1"
- "Trigger" as "Digital Trace 2"

as in **Fig. 4.25**.

Note: Any time you change one setting, always press "Apply" to make the setting effective. Otherwise, press "Auto Apply" once for automatically applying the changes.

Note: "Gain" and "Offset" of the "Digital Traces" are digital controls, so they affect only the traces visualization, while they have no impact on the internal board filters.

Note: move the "Waveform and Pre-Trigger Length" slider to increase or decrease the waveform visualization length.

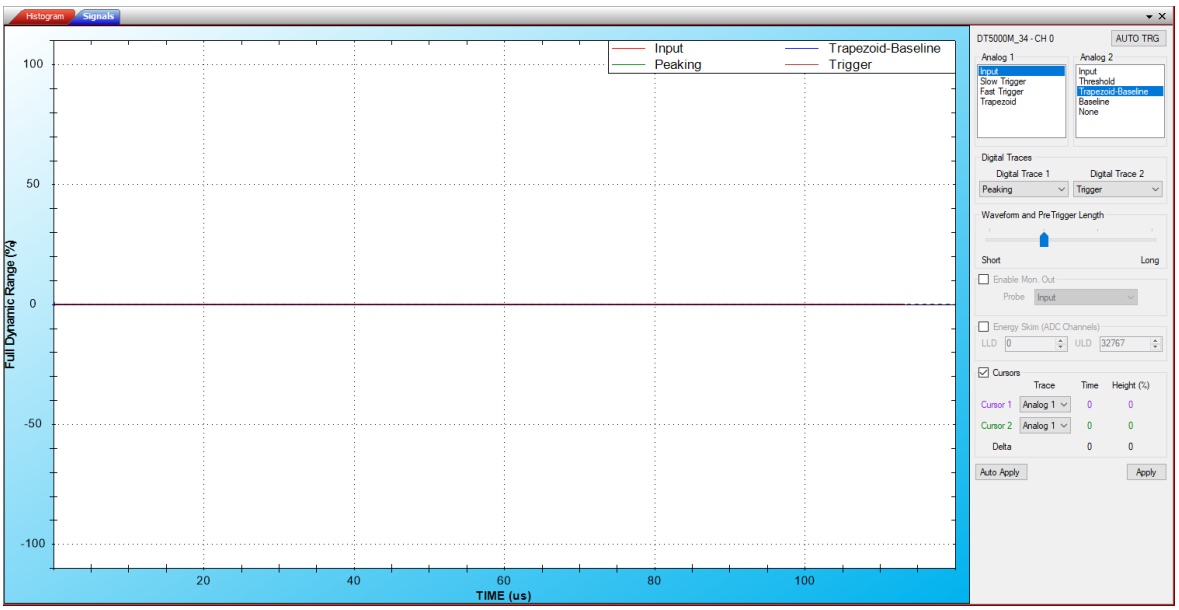


Fig. 4.25: Default signal inspector graphical interface

Press PLAY to start the waveforms visualization.

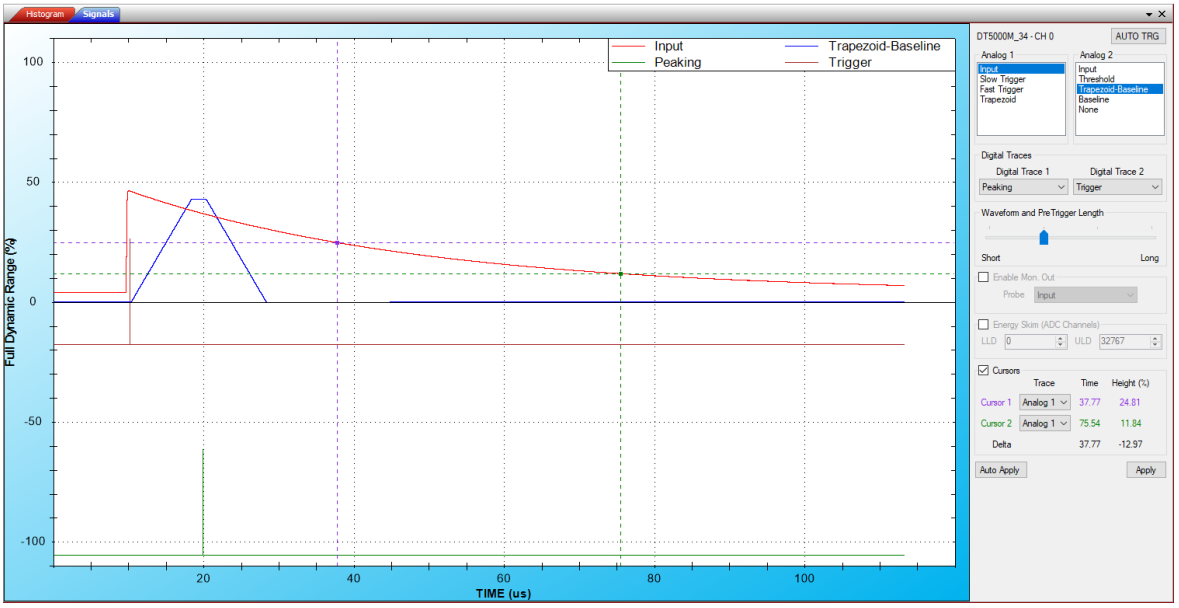


Fig. 4.26: Signal inspector visualization of Input, Trapezoid-Baseline, Peaking and Trigger traces

Note: In case any signal is displayed, press “AUTO TRG” to enable the software-trigger. The software will force the board to trigger the events. Then, adjust the channel settings as described in the following sections. Once the parameters are correctly set, release the AUTO button to disable the software-trigger.

Adjust the waveform length for a better visualization (see **Fig. 4.27**).

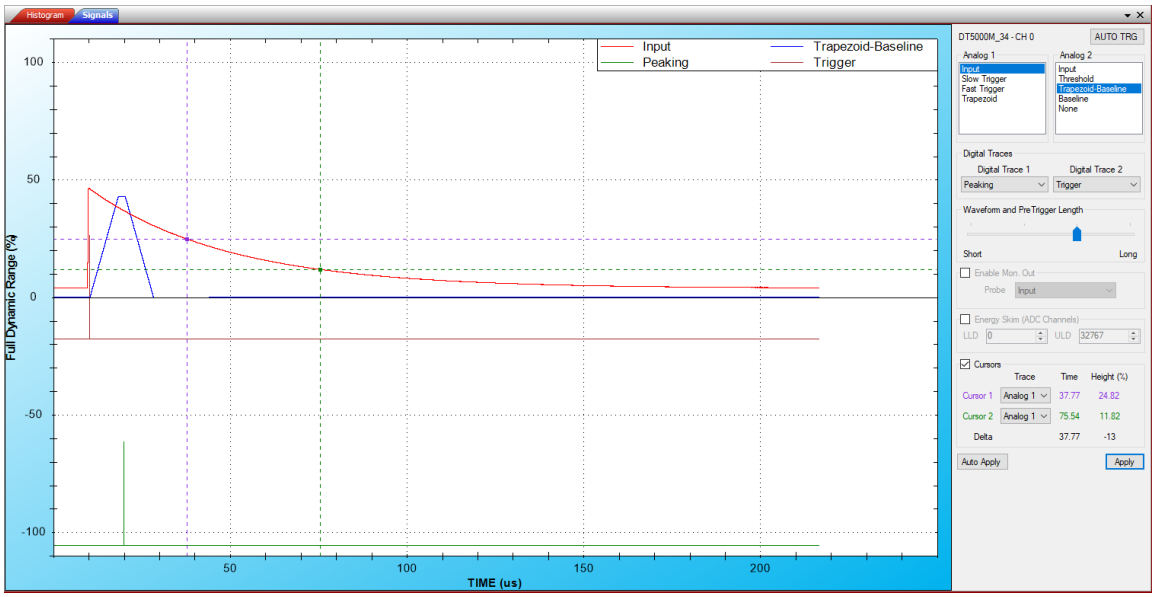


Fig. 4.27: Modification of the "Waveform and Pre-Trigger Length" slider for a better visualization of the waveforms

Drag and release to zoom in a region of the plot.

Right click and select "Un-zoom" or "Un-zoom all" to zoom out.

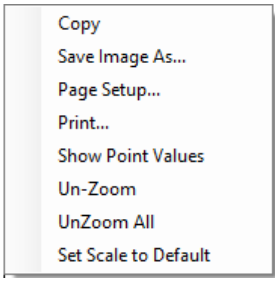


Fig. 4.28: Zoom-out options

How to Configure the Input Signal Settings

The first settings to be configured are those related to the Input Signal.

1. Open the “Acquisition Setup” window, either from the button or from “Tools -> Acquisition Setup”.

The channels for which settings are going to be modified are automatically selected according to the currently active spectrum selected in the Spectra List window. In the current example, the channel is identified by the label *Digitizer Family_Serial Number – CH n*: “DT5000M_XXX – CH0”. The input signal settings are in the first tab “Input Signal”.

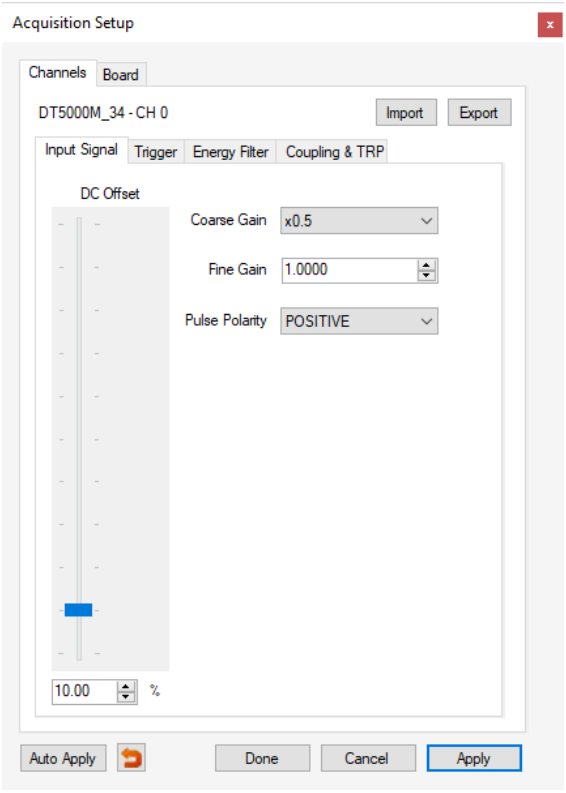


Fig. 4.29: The Acquisition Set Up Window – Channels Tab – Input Signal Tab

2. Using the measurement of the pre-amplified pulses from an oscilloscope device (refer to Sect. **Before Starting the Acquisition**), it is possible to check what is the pulse height range.

It is important to select the proper “Coarse Gain”, which corresponds to the input dynamic range of the MCA, to get all the pulses, even in pile-up. Possible Hexagon options are x0.25, x0.5, x1, x2, x4, x8, x16, x32, x64, x128, x256. The correct setting of the Input Range is a compromise between the digitizer dynamics saturation and the use of too few channels of the spectrum. In general, an higher gain allows to have a better signal/noise ratio but at the same time it cause a lost in the dynamic range ie the maximum energy value in the spectrum.

In the example of this sections, we choose the x1

3. Keep the “**Fine Gain**” value to 1. It can be adjusted later to move the spectrum peaks to the desired position.

4. Select the input “**Pulse Polarity**” choosing among “**Positive**” and “**Negative**”. Since the algorithm works with positive pulses only, by setting “Negative” the algorithm will invert the digital samples of the input.

Adjust the “**DC Offset**” to have the input signal baseline around 5-10% of the dynamic range. You can safely go below this value, only check that the input does not saturate around 0. In that case the algorithm stops any calculation and increases the dead-time. It is also important to check that the signal does not saturate in the upper limit of the dynamics (100% of the dynamic range). In our example we set DC Offset = 10%.

The result of these settings is shown in **Fig. 4.30**.

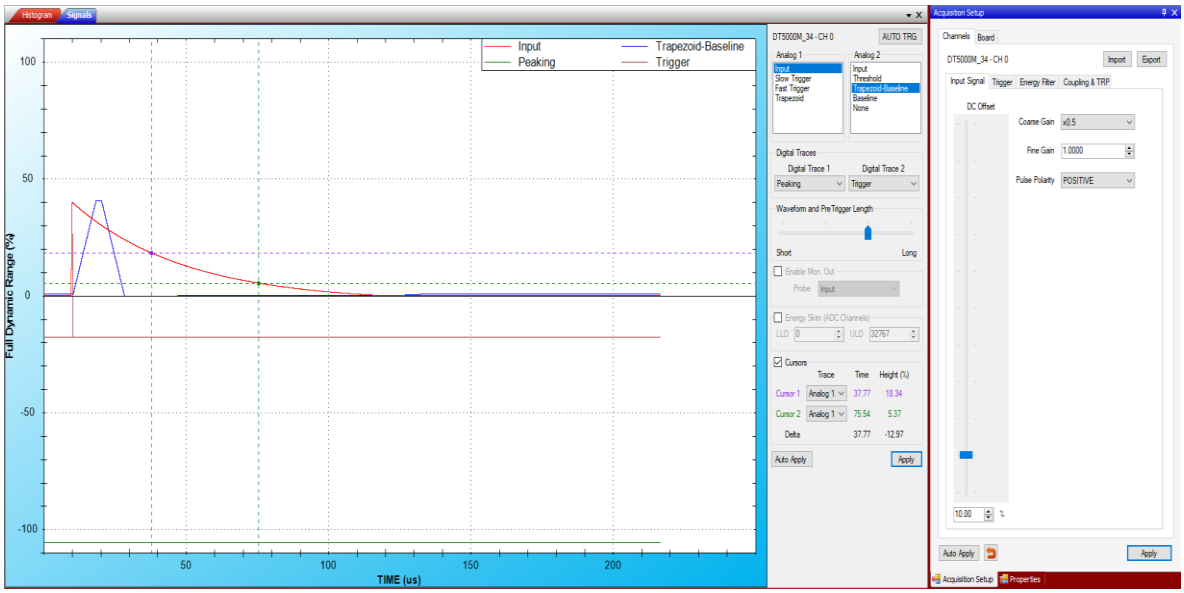


Fig. 4.30: "Input Signal" settings and corresponding effect on the signal inspector window

How to set the Trigger Filter

Since the trigger fires at the zero-crossing of the triangular filter signal (refer to **[RD1]** for further details) first enable the visualization of the:

- "Fast Trigger" as "Analog Trace 1"
- "Input" as "Analog Trace 2"

Select the tab "Trigger" from the "Acquisition Setup" window.

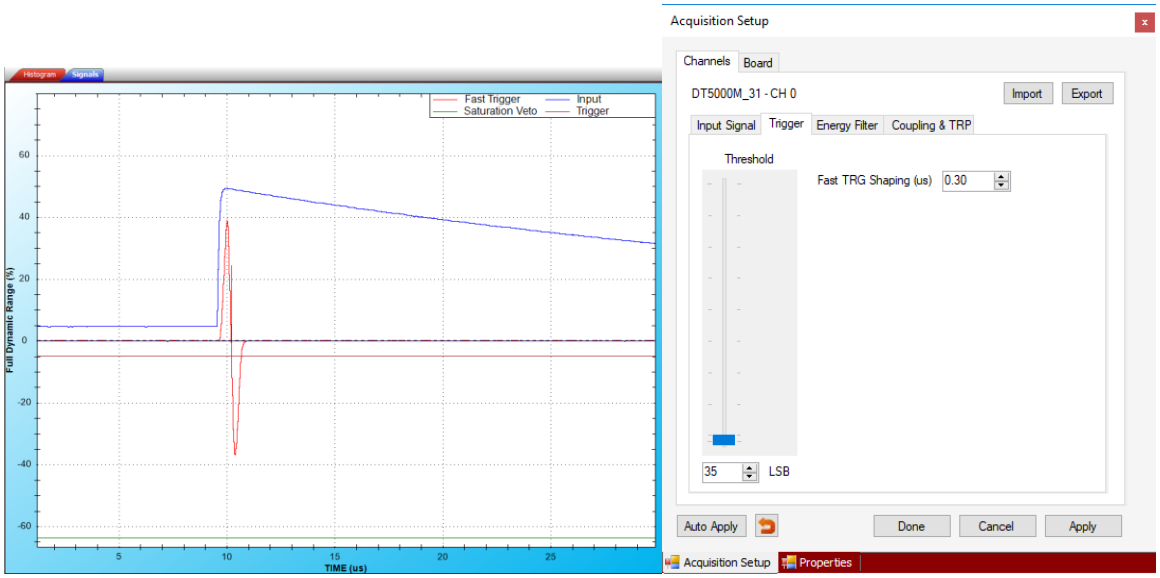


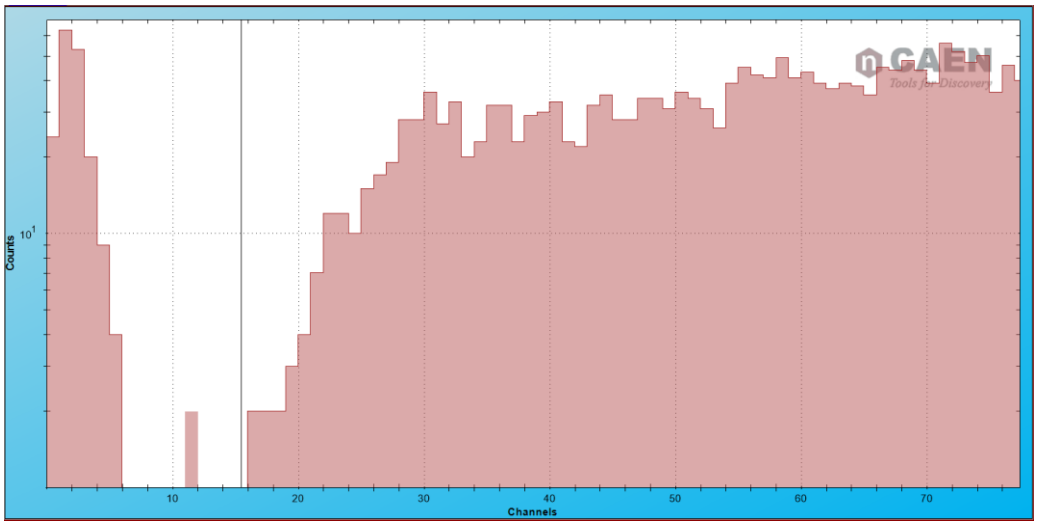
Fig. 4.31: "Trigger" tab settings and the visualization of the RC-CR2 settings and corresponding effect on the signal inspector window

Choose the desired value of **"Fast TRG Shaping"** from a range of 0.01 to 0.8 µs.

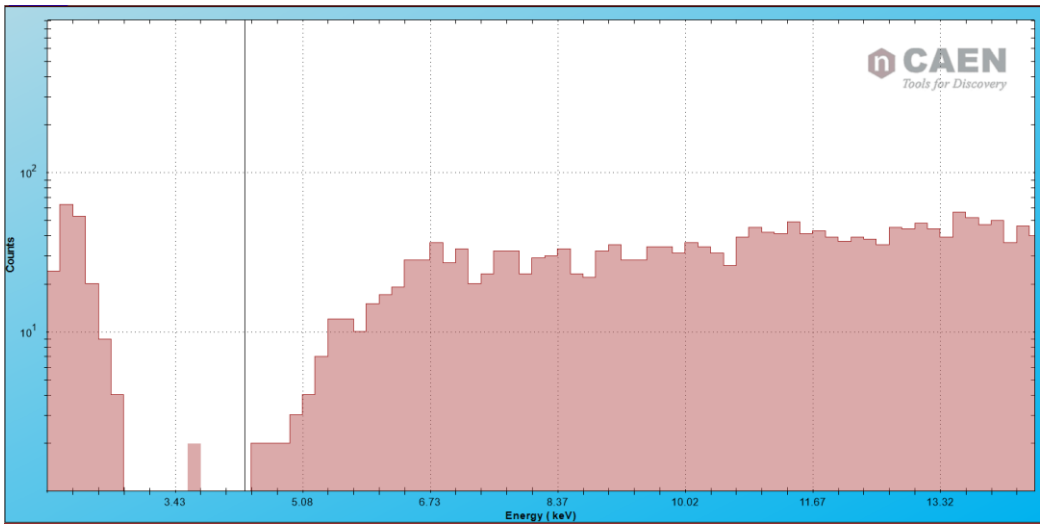
The correct value for our example is **0.3 µs**.

Set the **Threshold** value to avoid the noise level of the fast trigger itself and arm the trigger filter. The trigger will fire on the derivative signal of the fast trapezoid.

To correctly set the Threshold value, switch to the **"Histogram"** window. Zoom in in the lowest region of the spectrum and reduce the threshold level until you get a peak close to zero. You are now triggering below the noise level. Set then a value slightly higher to trigger on real pulses.



In our example, we can reach up to about 5 keV.



How to set the Energy Filter

The precise configuration of the Energy Filter strongly affects the final resolution measurement; therefore it is very important to fine tuning the Energy Filter settings. The user must take care of:

- Checking that the trapezoid is correctly shaped;
- Evaluating the energy value (see the Peaking trace) in the flat top region of the trapezoid.

The two typical measurement setups that we are going to discuss are:

1. Low rate (up to few hundreds of Hz) and very high precision measurement;
2. High rate (up to tens of kHz), where the result is a compromise between high resolution and low dead-time.

Before starting, set an approximate value of **"Decay Time"**. The fine tuning of this parameter is described in section **Digital Pole-Zero Adjustment**.

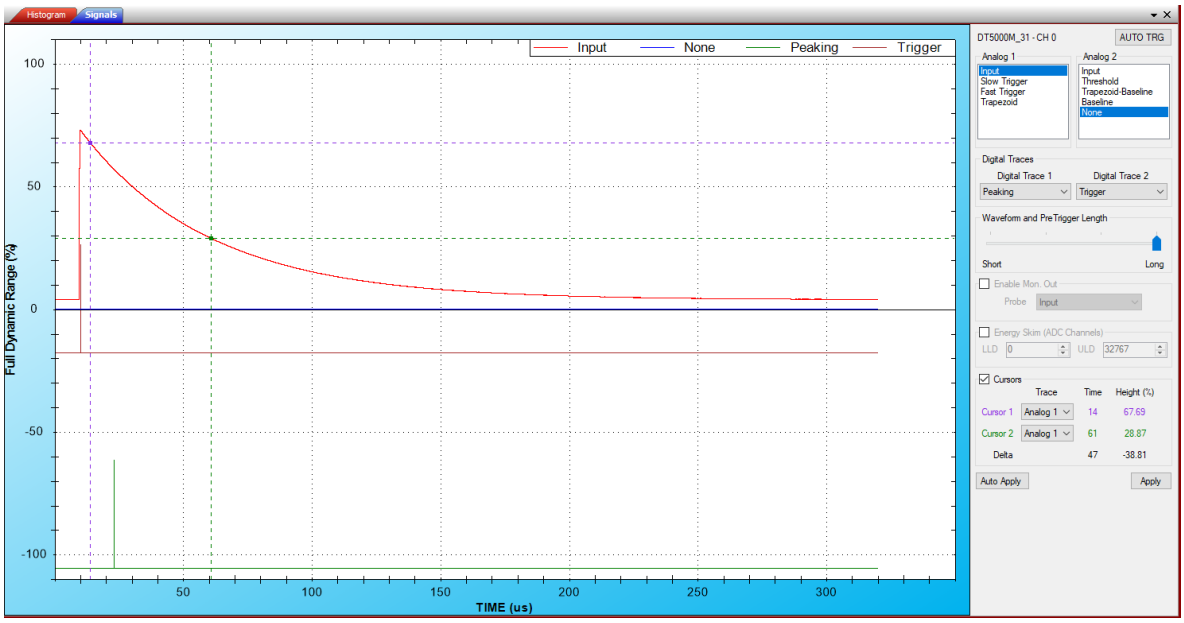
To evaluate the decay time value the user can enable the "Input" visualization from "Analog Trace 1", and measure the input *half-time* using the "Signal Inspector Cursors". From the half time it is possible to calculate the decay time according to the formula: $T_{1/2} = \ln(2)\,\tau$, where $T_{1/2}$ is the half time, and τ is the decay time.

The cursors are automatically displayed on the Signal Inspector window

Left click to point the **violet cursor**.

Press the "Shift" key and left click to point the **green cursor**.

Check the corresponding cursor values and their difference in the "Cursor" section. In the same section the user can also select at which trace (analog or digital) the cursors have to be applied.



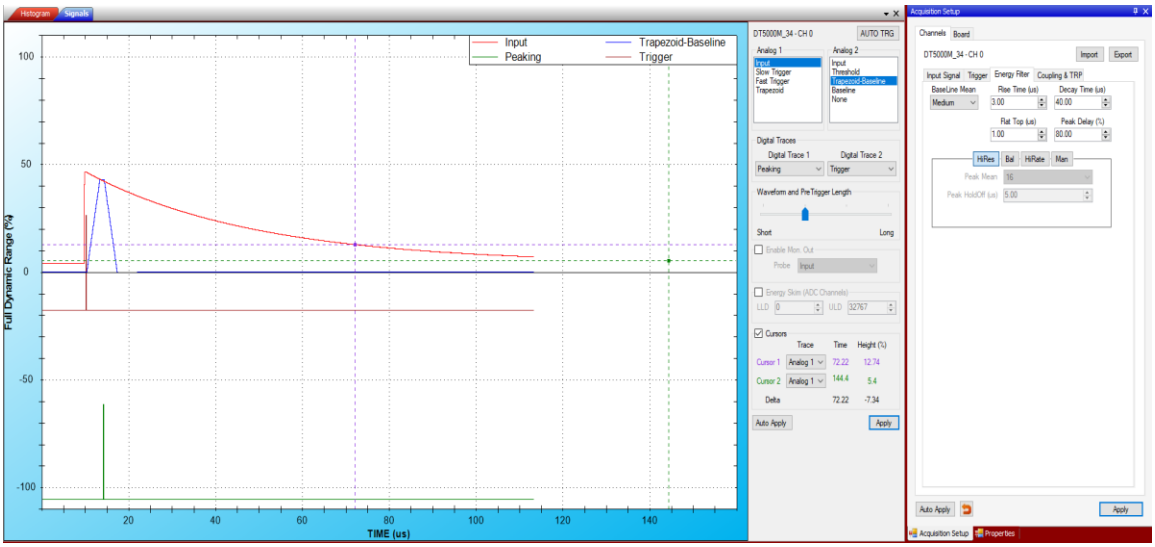
Select now:

- "Input" as "Analog Trace 1"
- "Trapezoid-Baseline" as "Analog Trace 2"
- "Peaking" as "Digital Trace 1"
- "Trigger" as Digital Trace 2

Note: The baseline of "Trapezoid - Baseline" trace should be at 0.

1. In the *low rate case* it is recommended to set a high value of **"Trapezoid Rise Time"**, as for example **8 µs**. Considering it in the analogy of the analog chain (refer to **[RD1]**) it corresponds to about 3 µs of shaping time.
   Then set a value of **"Trapezoid Flat Top"** between **1-2 µs**, only check that the flat top region is really flat.
   Adjust – if necessary – the Peaking position (**"Peak Delay"**) and the number of samples (**"Peak. Mean"**) for the energy mean calculation.
   It is advisable to always use the **Medium** value of **"Baseline Mean"** (i.e. the number of samples for the baseline calculation), unless very special setups are involved in which the low frequency noise is negligible.

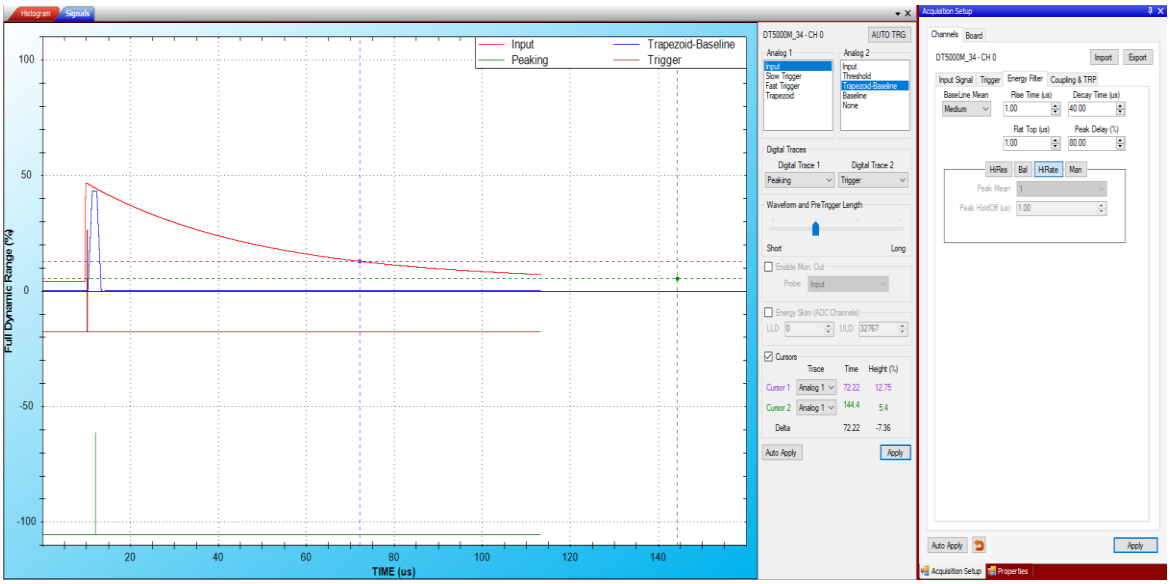
   You can either choose the preset **"HiRes"** for high resolution settings, or the **"Man"**.



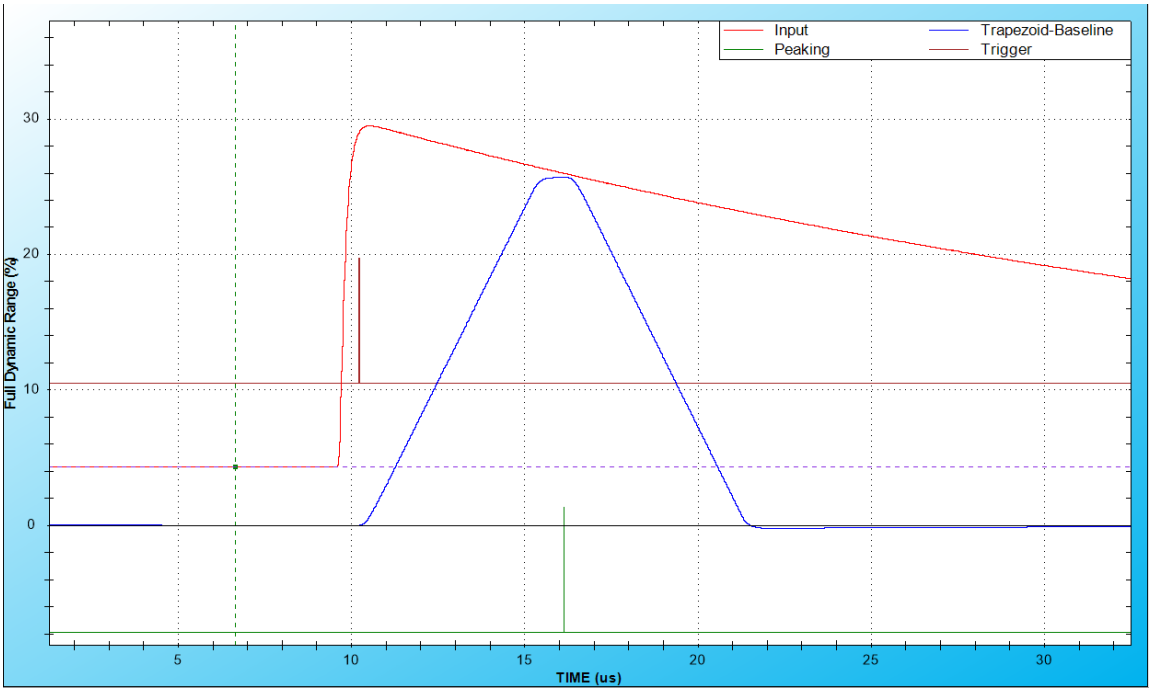
Note: Trapezoid Rise Time and Flat Top Time have a maximum value of about 40.95 and 20.47 µs. In any case their sum should not exceed 40.95 µs.

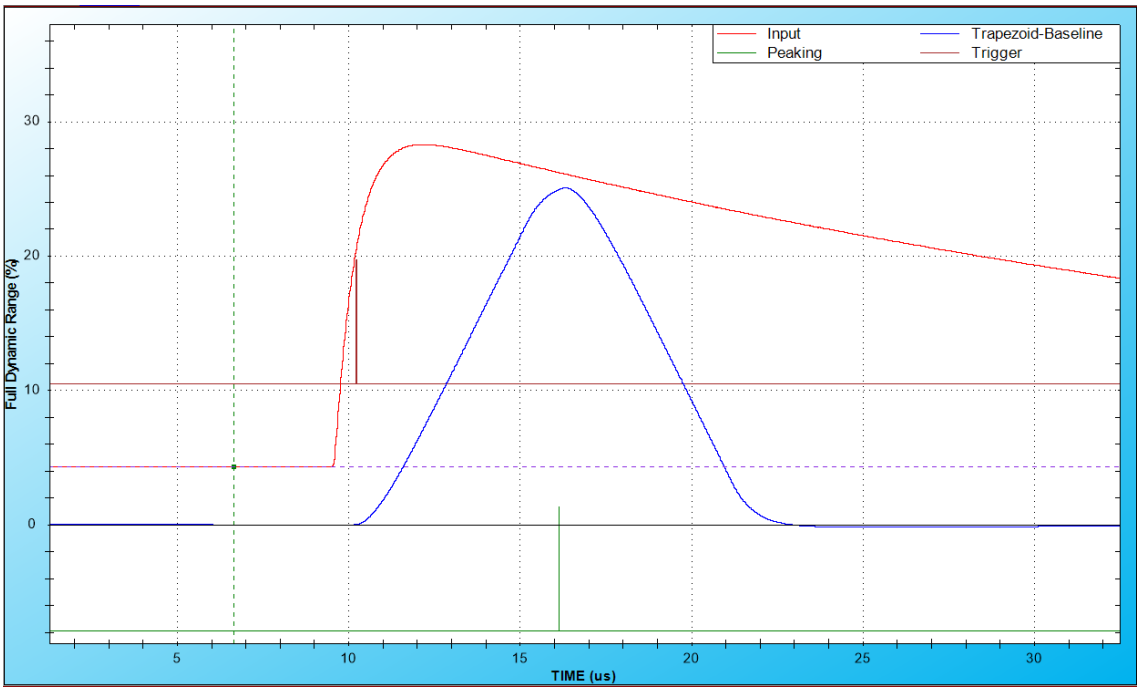
1. In the *high rate case* (tens of kHz) it is recommended to set a lower value of **"Trapezoid Rise Time"**, as for example **3-4 µs**. For a rate greater than 20 kHz it might be convenient to set **"Trapezoid Rise Time" = 1 µs**.
   Set also **"Trapezoid Flat Top" = 1 µs**, only check that the flat top region is really flat.
   Adjust – if necessary – the Peaking position (**"Peak Delay"**) and the number of samples (**"Peak. Mean"**) for the energy mean calculation in the flat region.
   Still it is advisable to always use the **Medium** value of **"Baseline Mean"** or the **Fast** one taking into account that in this case some high frequency noise could be picked up. A dedicated study of the impact of the Baseline Mean in the final resolution can be made.

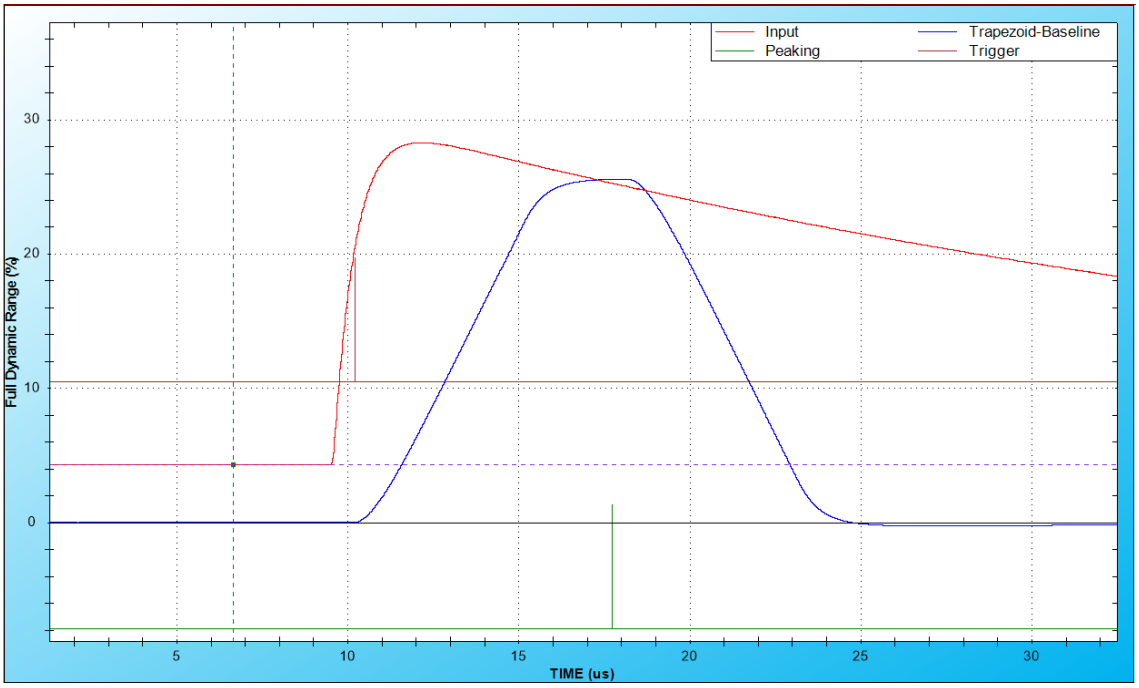
   You can either choose the preset **"HiRate"** for high rate settings, or the **"Man"** settings for manual adjustments.



Both in case of low rate and high rate it is very *important* to have a flat "Flat Top" region. The Flat Top depends on the charge collection time and so on the input signal rise time. In the following pictures some example of this dependence is shown.







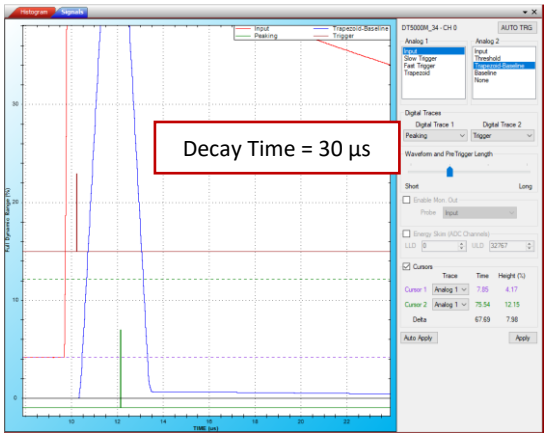
In the top figure a 200 ns rise time input signal and the corresponding 1 µs Flat Top trapezoid is shown, in the middle figure a 800 ns rise time input signal and the corresponding 1 µs Flat Top trapezoid is shown, in the bottom figure a 800 ns rise time input signal and the corresponding 1 µs Flat Top trapezoid is shown. The ballistic effect is much reduced in the third case with respect to the second one. The trapezoid rise time is 5 µs in all the cases.

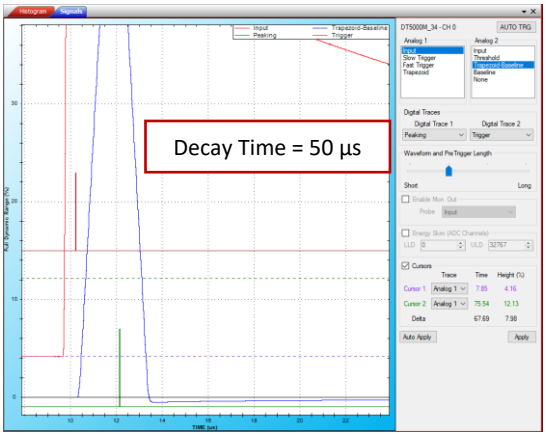
The **"Peaking"**, which corresponds to the samples where the pulse energy is evaluated, should be taken in the flat region. Adjust the **"Peak Delay"** and the **"Peak Mean"** values accordingly.

Digital Pole-Zero Adjustment

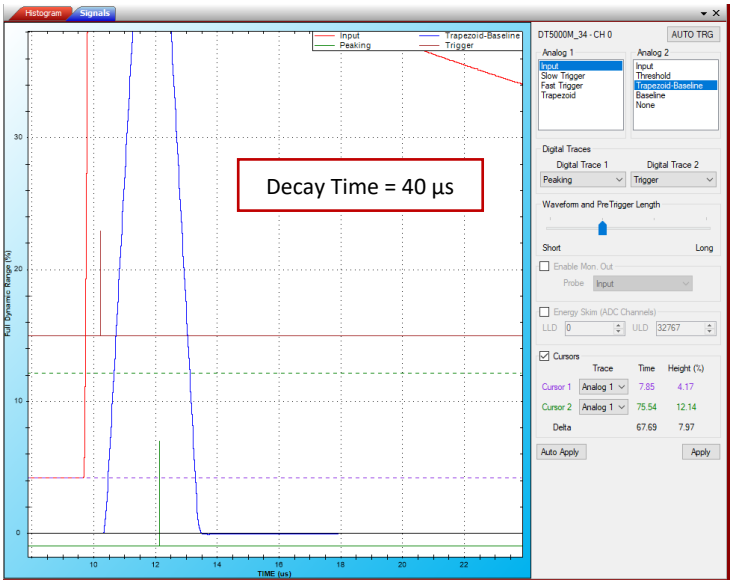
The pole-zero adjustment is very important for a correct evaluation of the trapezoid baseline and consequently for a correct evaluation of the energy value.

The user must adjust the **"Decay Time"** according to the Pre-Amplifier decay time. Fine adjustments can be done looking at the zoom of the Trapezoid trace (or Trapezoid-Baseline) in order to have no undershoot nor overshoot. The two cases are shown in the following figure, where on the left the Decay Time has been set too high giving an undershoot, and on the right the Decay Time has been set too low thus giving an overshoot.





When the Pole-Zero is correctly compensated, the Trapezoid will not make any overshoot nor undershoot.

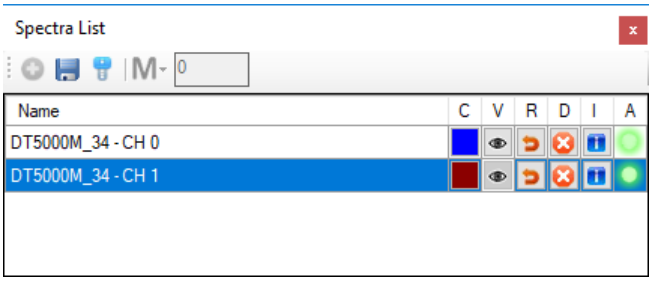


Start/Stop the acquisition

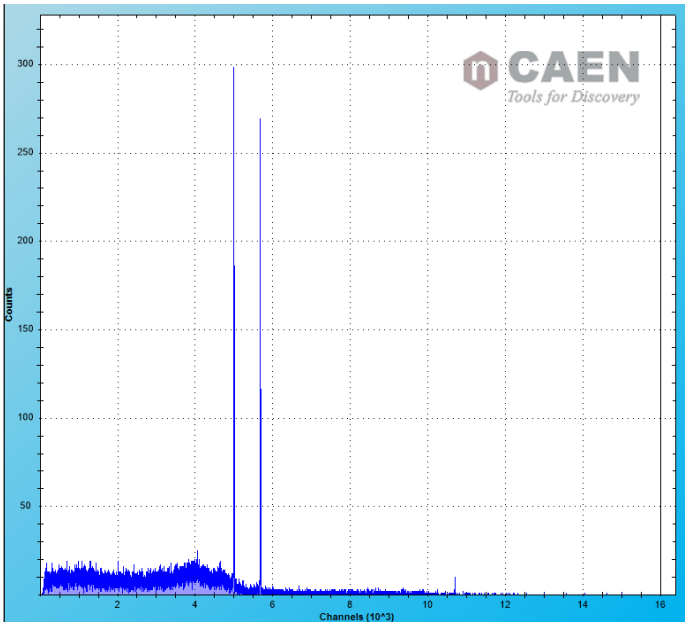
Once you have configured the acquisition, close the **"Signal Inspector"** Window.

Select **"Default Spectrum"** from the **"Spectra list"** window. Click **"R"** to reset all spectra, or to reset the single spectrum.

Then press PLAY to start the acquisition, STOP to stop it. When you select them from the Spectra List window you start/stop only the selected spectrum. If you select them from the main GUI you start/stop all channels.

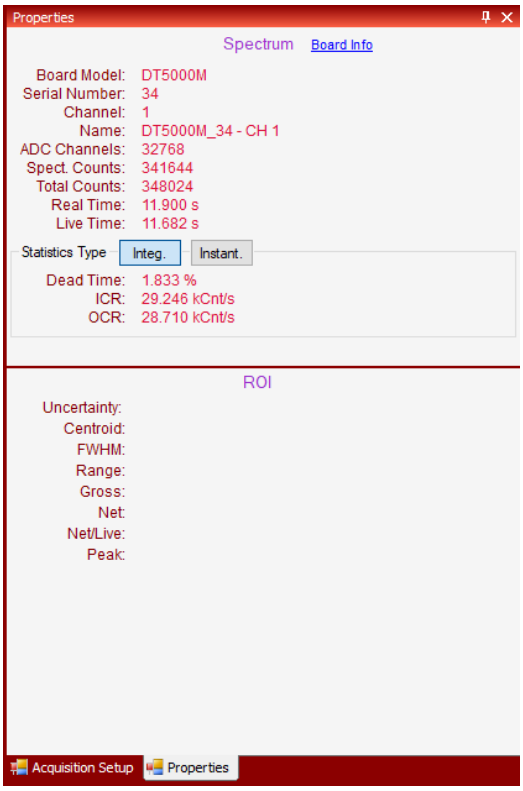


Note: The circle under "A" becomes RED in case of dynamics saturation or busy of the data throughput.



Enable the **"log scale"** if needed , and the **"vertical auto-scale"**

Check the spectrum properties from the **"Properties"** window:


Properties
Spectrum
Board Info
Board Model: DT5000M
Serial Number: 34
Channel: 1
Name: DT5000M_34 - CH 1
ADC Channels: 32768
Spect. Counts: 341644
Total Counts: 348024
Real Time: 11.900 s
Live Time: 11.682 s
Statistics Type
Integ.
Instant.
Dead Time: 1.833 %
ICR: 29.246 kCnt/s
OCR: 28.710 kCnt/s
ROI
Uncertainty:
Centroid:
FWHM:
Range:
Gross:
Net:
Net/Live:
Peak:
Acquisition Setup
Properties

How to calibrate a spectrum

The software allows the user to calibrate a spectrum from counts to keV using two interpolating functions: Linear and Quadratic. For the first function the user must define at least a couple of values, while for the second the user must define at least three values. It is also possible to define more points; the algorithm will then compute the best fit of the defined points. For more details about the energy calibration refer to **[RD1]**.

The user can select a Region of Interest (ROI) of the spectrum and take the mean value of the distribution for the energy calibration.

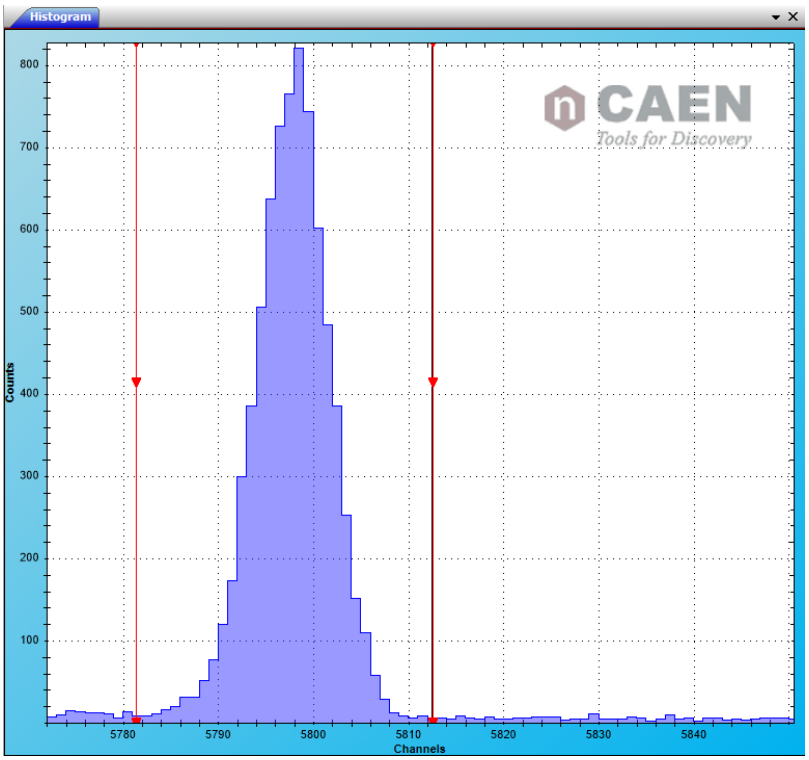
How to select a ROI

Zoom in (drag and release the mouse to zoom in) in the region of the relevant peaks to select the ROI.

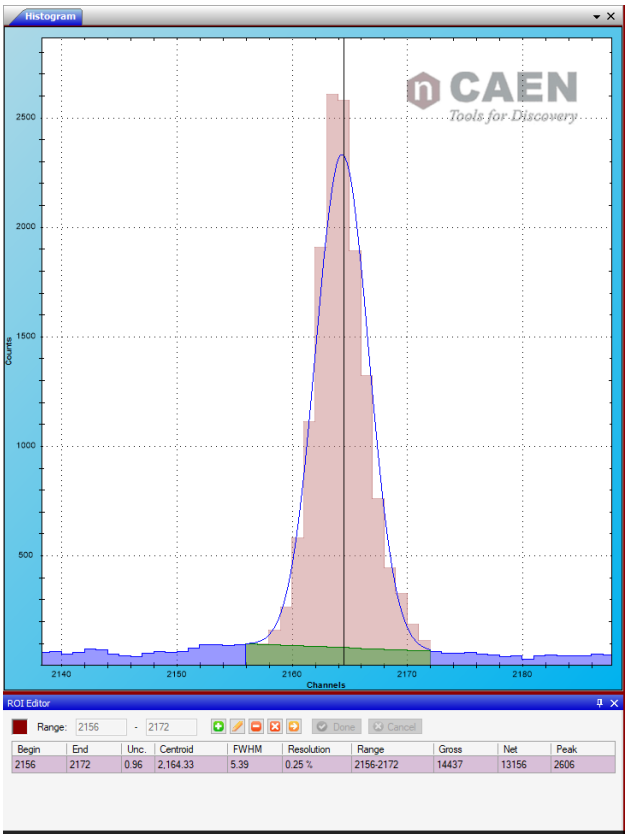
From the "ROI Editor" window select "Add"  .

Click on the histogram to select the left and right limits of the ROI.

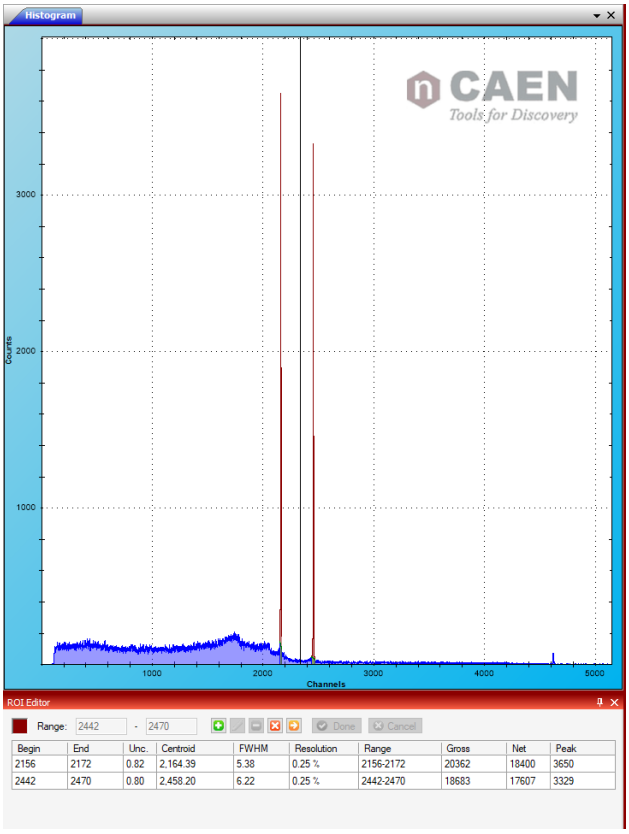
Then press "Done" from the ROI Editor window.



Left click on the ROI to check the fit and to get the parameters. Check **[RD1]** for more details about the ROI fitting.

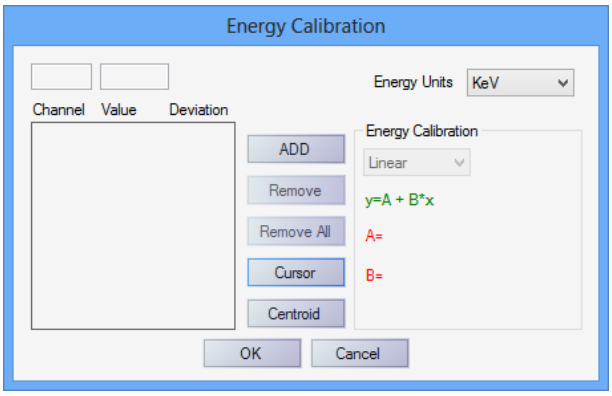


Repeat the same procedure for the second peak:

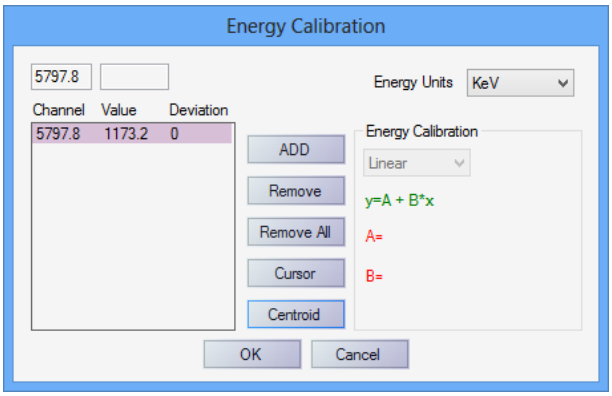


Energy calibration

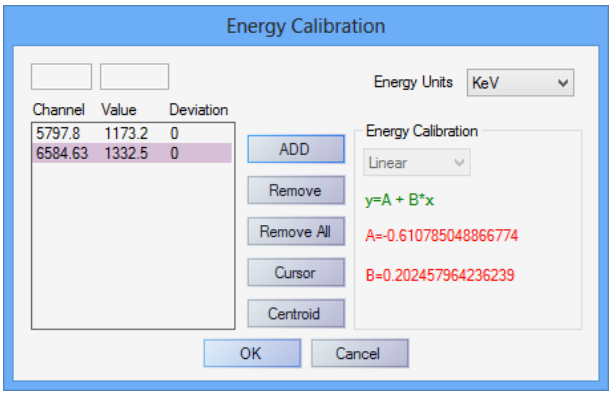
Pause the spectrum and open the **"Energy Calibration"** window :



Click on the first ROI and select **"Centroid"** to use the centroid value of the distribution. Write the desired value of energy, then click **ADD.**



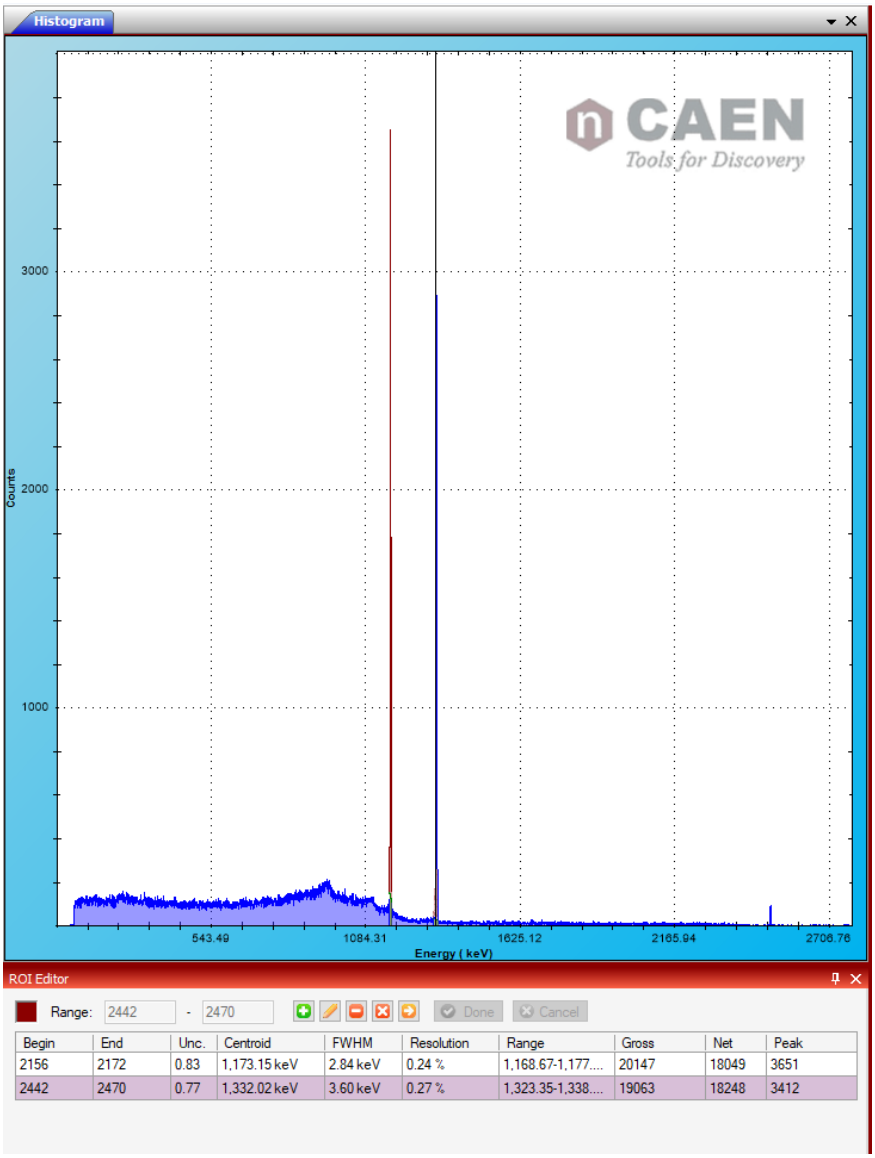
Repeat for the second ROI, then click **OK**



Press "Enable Calibration" to enable the calibration of the spectrum. All the values on the ROI Editor window are automatically converted.

Note: The user can choose more than two points to perform the calibration. In case two points are used it is usually recommended to use values in a wide energy range. The more the difference is high the more the linear calibration will be accurate.

Note: It is also possible the perform a calibration with a single peak, by setting the second point to 0. Set "Channel" = 0 and "Value" = 0.


Histogram
CAEN
Tools for Discovery
Counts
3000
2000
1000
543.49
1084.31
1625.12
2165.94
2706.76
Energy (keV)
ROI Editor
Range: 2442 - 2470
Done
Cancel
Begin End Unc. Centroid FWHM Resolution Range Gross Net Peak
2156 2172 0.83 1,173.15 keV 2.84 keV 0.24 % 1,168.67-1,177.... 20147 18049 3651
2442 2470 0.77 1,332.02 keV 3.60 keV 0.27 % 1,323.35-1,338.... 19063 18248 3412

How to save data

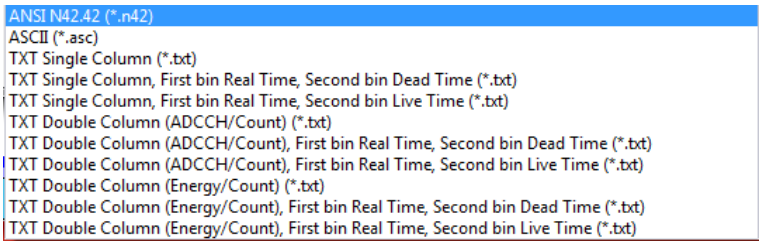
It is possible to save data in different ways:

1. Save the energy spectrum;
2. Save the list of Trigger Time Stamp and Energy for each event;
3. Save an image of the energy spectrum.

Save the energy spectrum

It is possible to save the energy spectrum through the path: **File->Save**, or using the command  .

Supported file formats are: .n42, .asc, .txt. For the .txt file there are several options, as shown in the following table.



In the .n42 file, the spectrum and the relevant properties are saved.

Save the list file

You can save the list file from the **"Acquisition Setup"** window, under the **"Board"** tab, select **"Output"**.

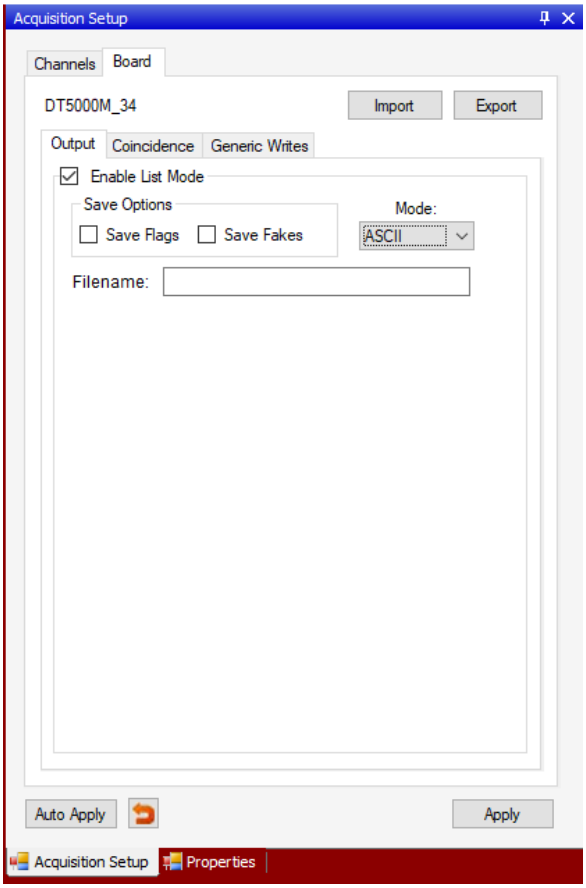
Click on **"Enable List Mode"** to enable the window.

By default the **Time Tag** and **Energy** information are saved in the list file. The user can select to save some additional information: **Flags** and **Fake Events.** More information about them can be found in **[RD1]**.

The list file is saved in the Hexagon local memory and can be accessed and download through the Web Interface (See **Web Interface** section for reference)

Binary and **ASCII** writing are selectable.

Start the acquisition to start dumping the list file. The dump will stop with the stop acquisition.

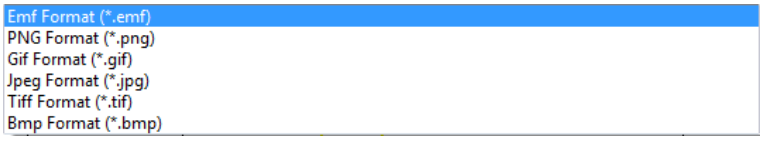


To avoid useless file generation, a warning message appears at the bottom of the GUI when the list dumping is enabled.

Note: remember to increment the file name index. In case of a new "start acquisition" the new data events will be added to the previous list file.

Save the Image

The user can export the spectrum in various image format, as listed in the following table.



From **"File"** click on **"Export"**. Otherwise right click on the spectrum and select **"Save Image As".**

How to make coincidence

The MC² Coincidence tab allows to operate Hexagon in **Coincidence/Anticoincidence** mode

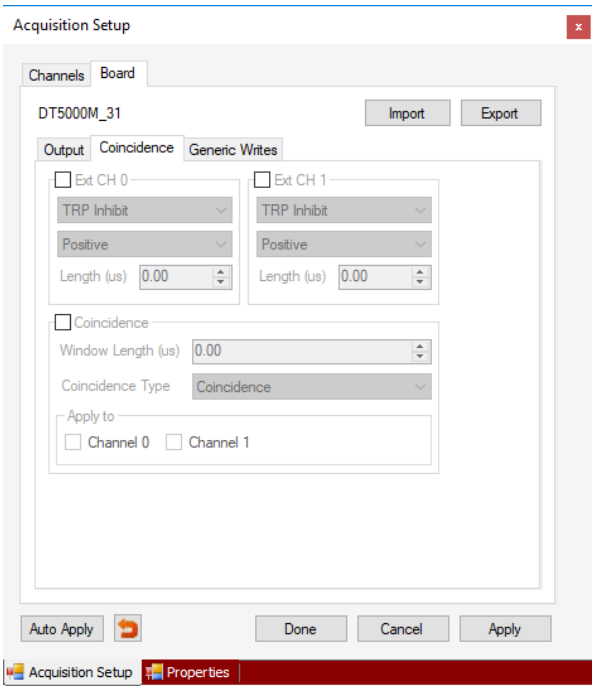
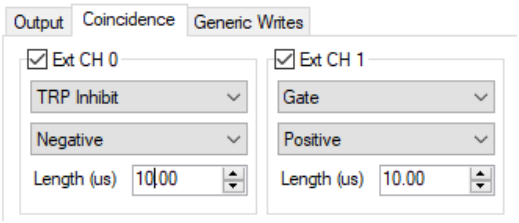


Fig. 4.32: The Acquisition Set Up Window – Board Section - Coincidences Tab.

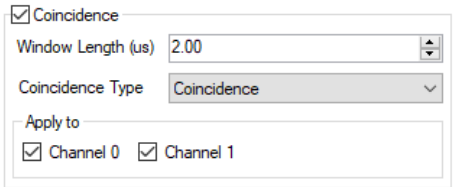
How to GATE/INHIBIT the acquisition

The top section of the tab allows the user to enable the two front panel TRP-INH/GATE input, to select the desired functionality (TRP-Inhibit or Gate), the signal polarity and length of the GATE/INHIBIT signal (in µs). Select the desired channel to enable/disable the VETO/GATE mode.



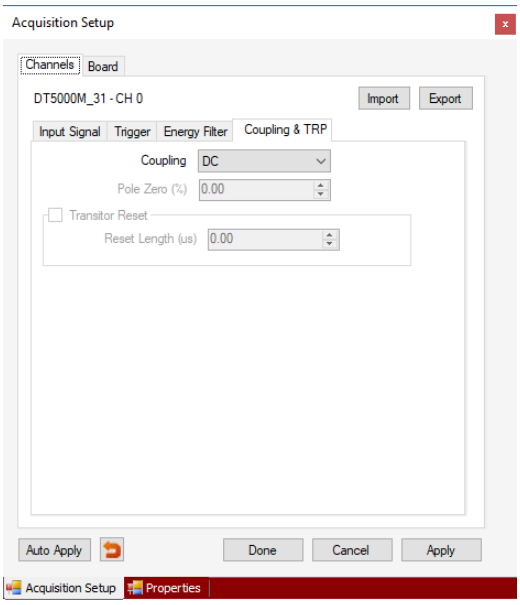
How to make coincidence between CH0 and CH1

The bottom section of the Coincidence tab allows to enable or disable the coincidence mode setting the coincidence Windows Length (in µs), the Coincidence Type (Coincidence or Anticoincidence) and the channel at which this mode has to be applied.



How to acquire from Resistive Feedback and Transistor Reset Preamplifiers

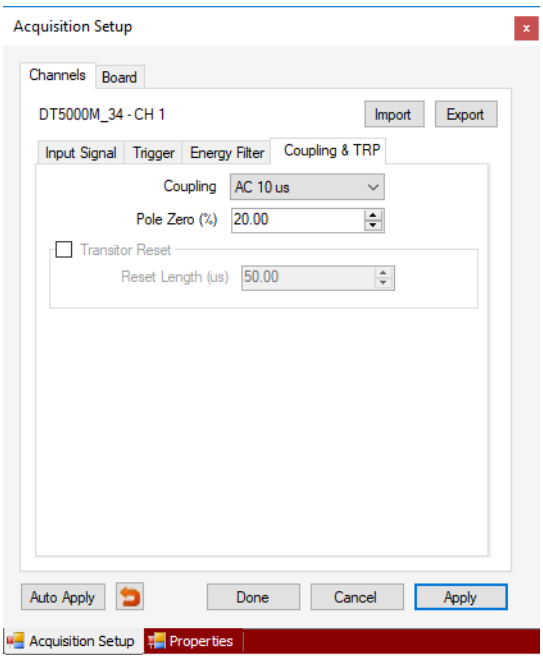
In order to operate with Transistor Reset Preamplifiers the user have to operate on the "**Coupling/TRP**"tab.

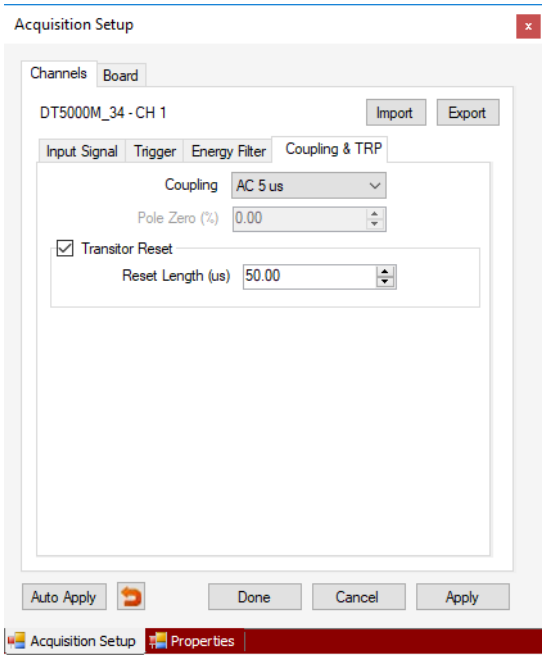


The user can select the input DC/AC coupling. **DC coupling** must be selected in case of Charge Sensitive Preamplifier, while **AC coupling** must be selected in case of Resistive Feedback and Transistor Reset Preamplifier. The user can choose between 5, 10 and 30 µs of shaping. In this case he/she must set the Trapezoid Decay Time according to set value.

In case of **Resistive Feedback** preamplifier the user have to compensate the **Analog Pole Zero** by setting the percentage value (left figure).

In case of **Transistor Reset** preamplifier there is no analog pole to compensate and the user has only to checkmark the corresponding box and set the **Reset Length**, i.e. the inhibit time due to the reset discharge. The latter should be set at a value at least equal to ten times the selected AC shaping time.





Troubleshooting

n	Issue	Possible Causes	Fixes
0	It is strongly recommended to first check from an oscilloscope device the signal from the pre-amplifier and check whether there is no grounding issue, and the pre-amplifier dynamics is not saturated.		
1	Though I decrease the "Threshold", I cannot reach lower values in the energy spectrum	The input signal is noisy and the trigger fires on the noise	Try to increase the **Fast TRG Shaping** time to reduce the fast filter sensitivity to the signal high frequency noise.
2	Values in the high region of the energy spectrum are cut off before the limit	The input signal is saturating the dynamics	Check from the **"Signal Inspector"** whether the **"Input"** pulse saturates the dynamics. Try to first adjust the **DC Offset**. Then you can try to change the **"Coarse Gain"**. It is preferable to modify the **"Fine Gain"** for a fine adjustment of the dynamics.
3	The peaks in the spectrum show an asymmetric left (right) tail	The pole-zero cancellation might be not correct. The baseline restoration can be overestimated/underestimated	Check from the **"Signal Inspector"** whether the **"Trapezoid"** trace correctly returns to zero.
4	The resolution is worse than expected	Some settings might be better tuned	In case of low rate it is worth to set high value of **"Trapezoid Rise Time"**, as well high value of **"Baseline Mean"**
5	The BUSY led is ON, i.e. the "A" circle under the Spectra List window is red	There might be a saturation or a memory full	Check point 2. Also check that the **Signal Inspector** window is closed.
6	There is too much dead-time in the acquisition	The input signal is saturating the dynamics	Check from the **"Signal Inspector"** whether the **"Input"** pulse saturates the dynamics. Try to first adjust the **DC Offset**. Then you can try to change the **"Coarse Gain"**. It is preferable to modify the **"Fine Gain"** for a fine adjustment of the dynamics.

Tab. 4.2: Troubleshooting table. For any other specific issue not listed in the table please contact CAEN at the support mailing list (Chapter 6).

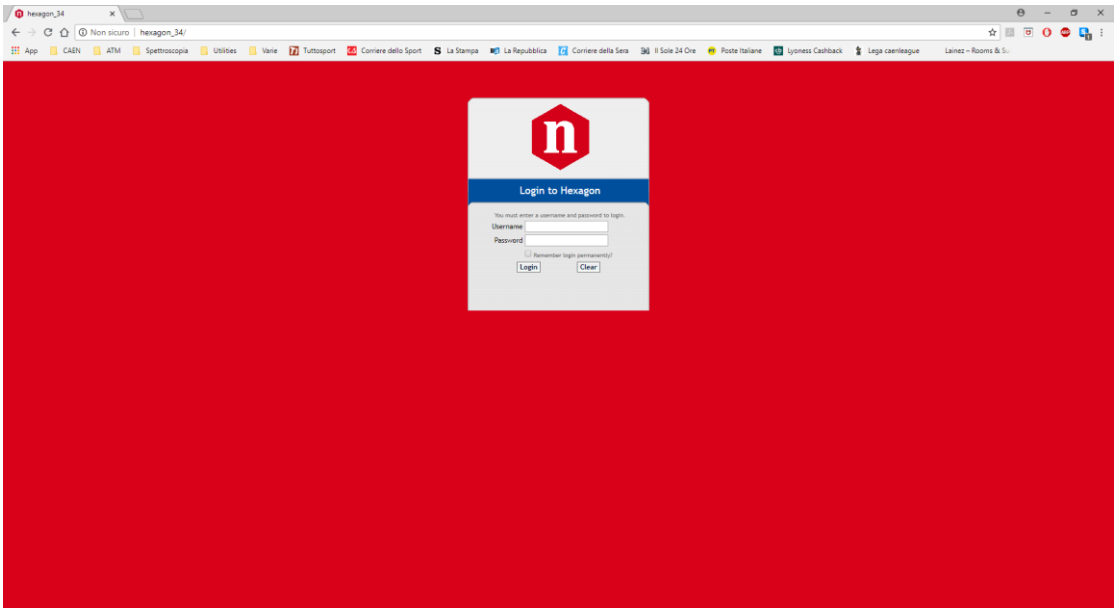
5 Web Interface

Note: Check that Hexagon is powered on, the Ethernet or the USB cable is connected, and the Network is configured according to Sec. **Network Configuration** and **Connecting to Hexagon**

If you are using the **Ethernet** connection open the web browser and type the IP Address of Hexagon as web address. In the default case, the IP Address is 172.16.0.2.

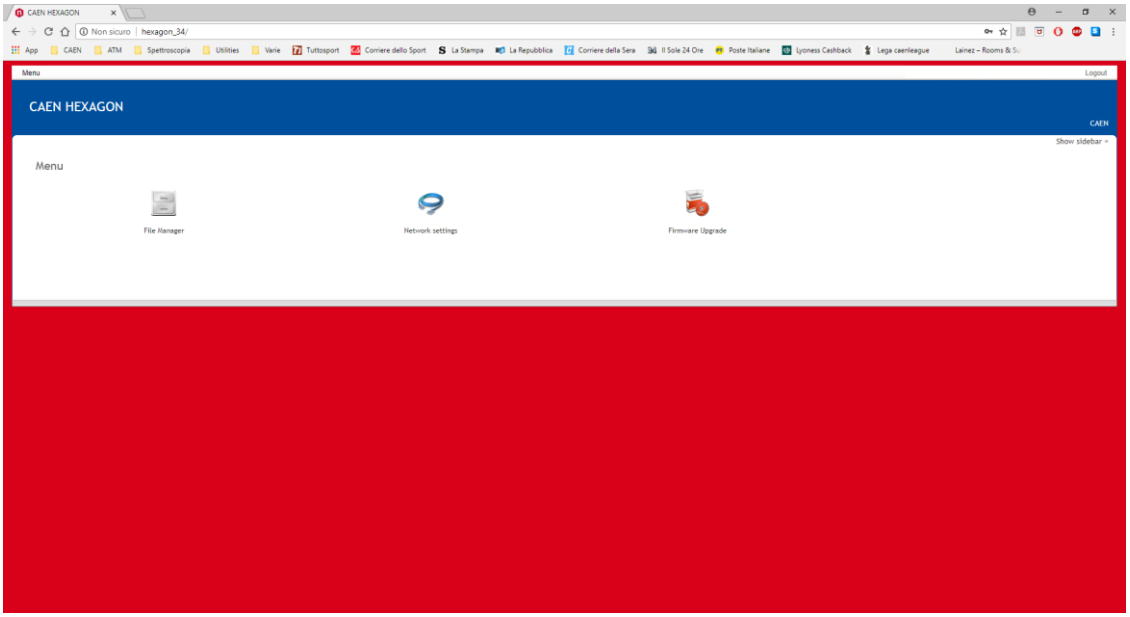
If you are using the USB connection open the Hexagon storage units and click on the **webserver.html** webpage or open the web browser and type **http://hexagon_XX** where XX is the Hexagon serial number.

Insert **Username = admin**, and **Password = admin** to login into the web interface.

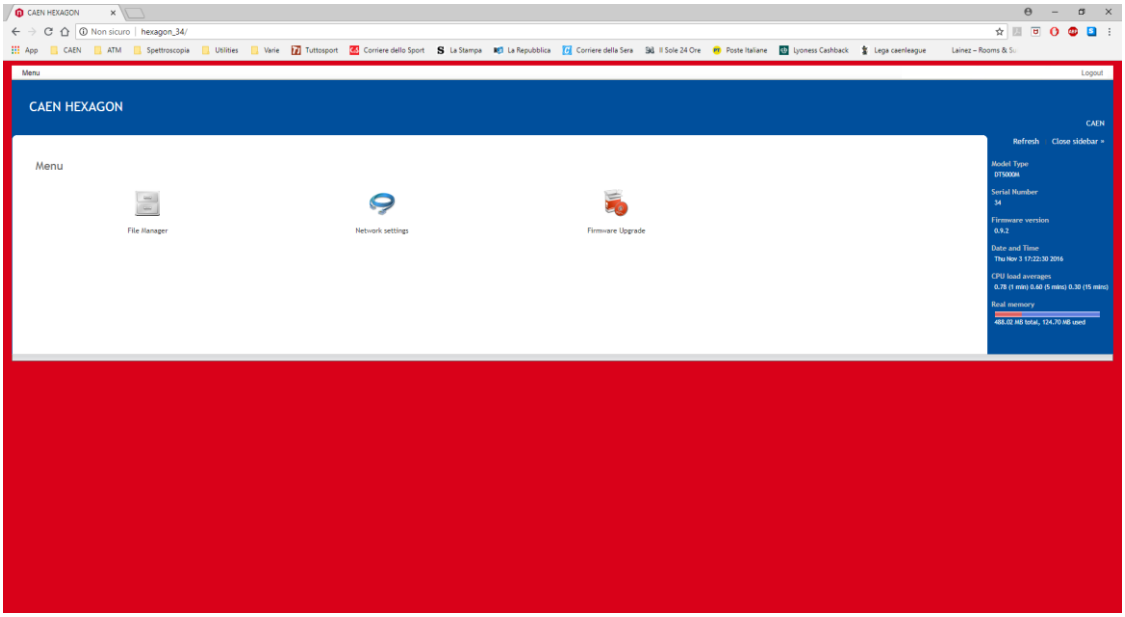


From the main page of the Hexagon web interface it is possible to select three items in the menu:

- File Manager;
- Network Settings;
- Firmware Upgrade.



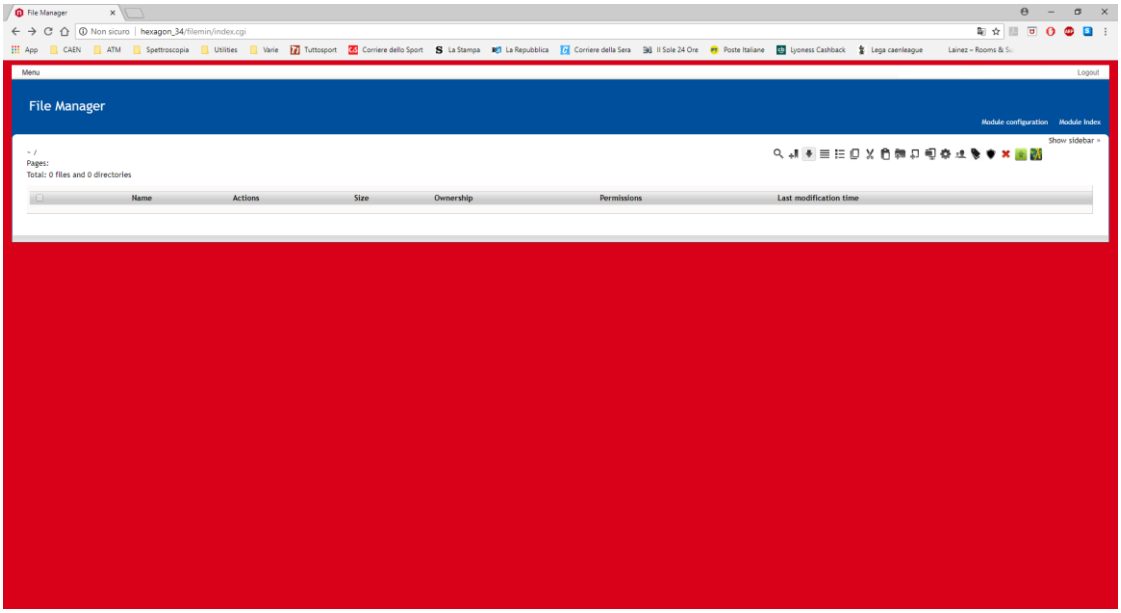
Click on the **Sidebar** label to get the information about Hexagon and the memory.



From the sidebar menu it is possible to get the Hexagon **Model Type**, its **Serial Number** and **Firmware Version**. Date and Time are also reported, as well as the information related to the internal **CPU load averages** and the **Real Memory**, corresponding to the RAM.

File Manager

In the File Browser menu it is possible to get the list of files saved into Hexagon. Selecting the desired run it is possible to download it on the local pc and/or to perform some operation (order, cut, copy, paste the files, creating and deleting directories, changing the right, etc) through the button in the operation ribbon

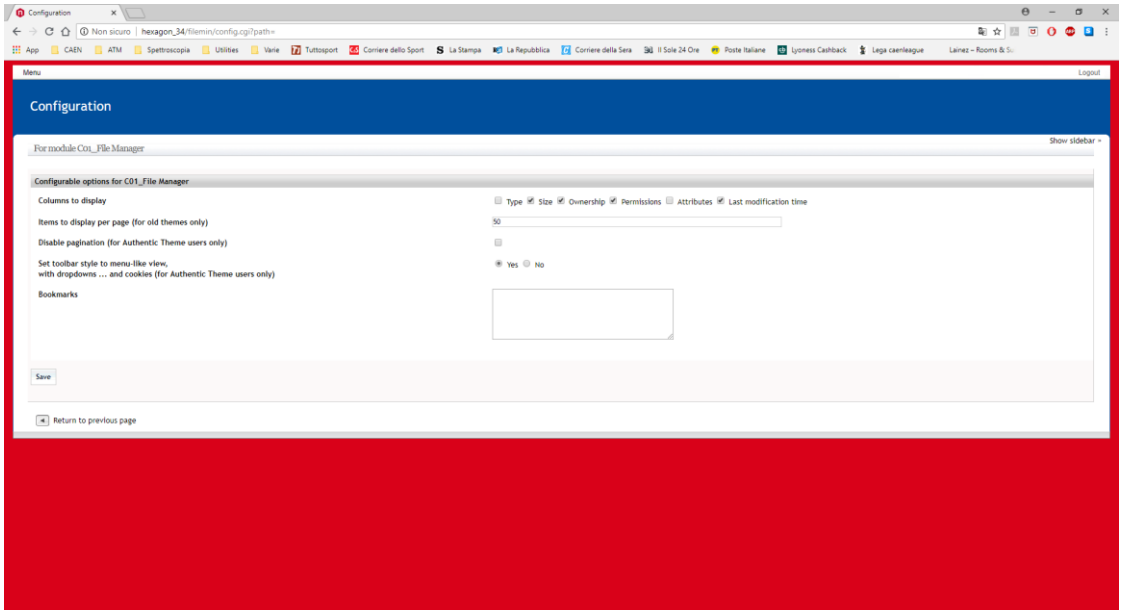


In the File Manager, each row is associated to a specific run and contains a set of information directly visible and related to the single file

- **Name**: the the name fo the data file
- **Actions:**

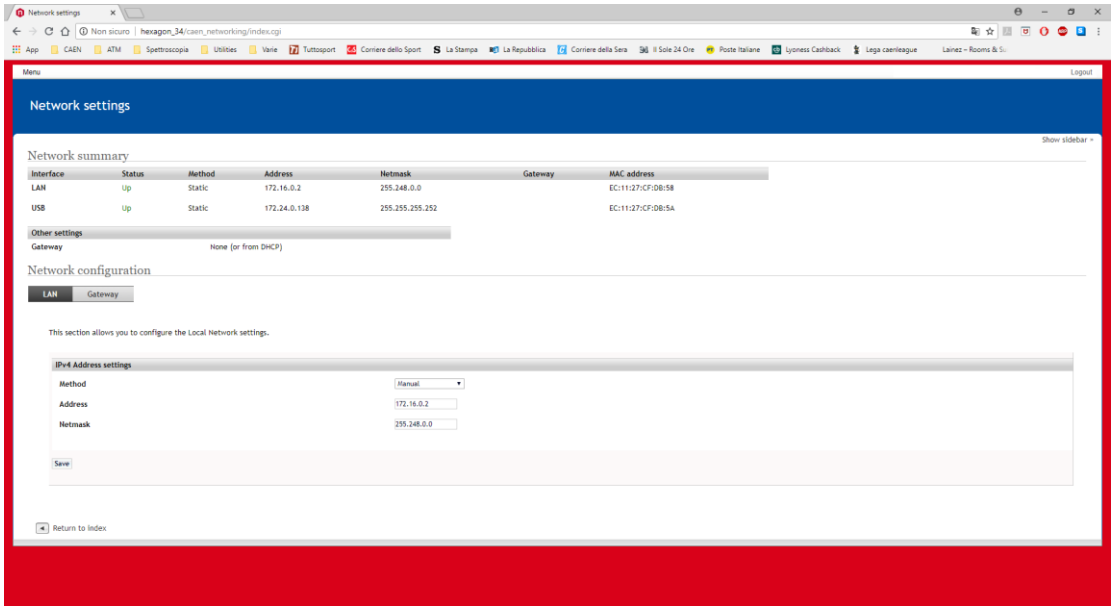
- **Size:** the size in bytes of the data file
- **Ownership**: the file owner
- **Permissions:** file read/write permission
- **Last modification time**: time of the last modification of the file

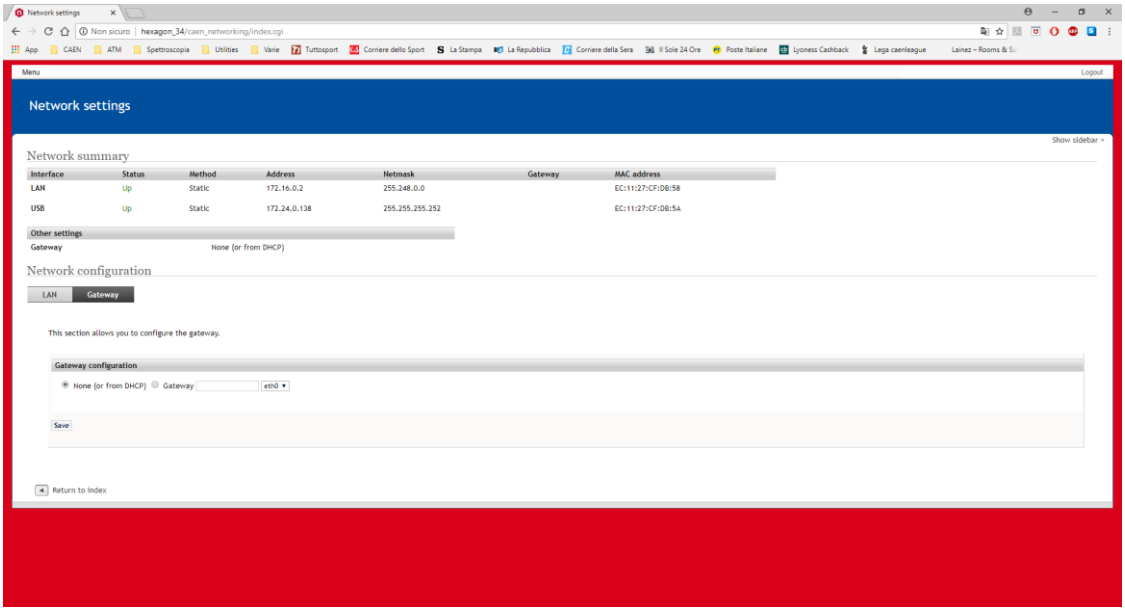
Clicking on the **Module Configuration** button a configuration window opens. From this page it is possible to configure the appearance of the File Manager section



Network Settings

In the Network Settings menu it is possible to get and modify the current IPv4 Address of Hexagon, to configure the LAN settings and Gateway, if required. If the IP Address is modified from the website interface, the network has to be configured again with the new settings.

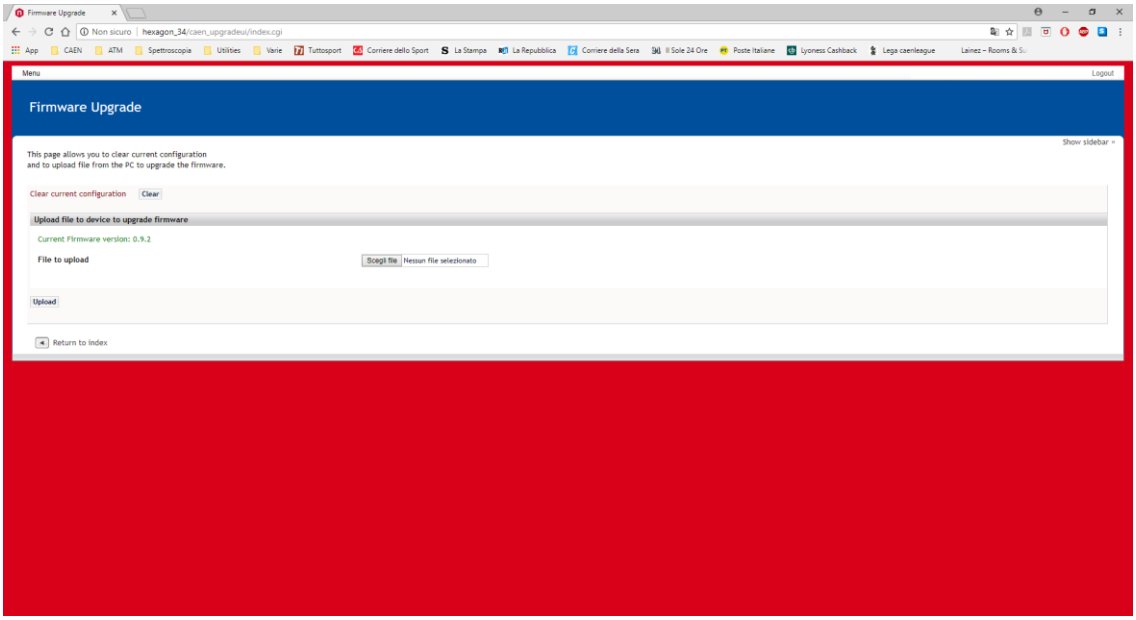




Note: In case of ETHERNET configuration loss for whatever reason, it can be modified again only by accessing via mini-USB link, which is managed as virtual ETHERNET with fixed configuration.

Firmware Upgrade

In the Firmware Upgrade menu it is possible to retrieve the current firmware revision and to upload a new firmware revision on Hexagon. Download the firmware file from CAEN web site, on the Hexagon product page. From the web interface use **Choose File** to point the file and press **Upload** to upgrade the firmware of Hexagon.



Note: Reboot Hexagon to complete the firmware upgrade.

In order to operate Hexagon at the best, it is recommended to keep the firmware always updated to the latest web available release!

6 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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