Rev. 0 - May 8th, 2025

Thanos

DAQ Software for Nbrick Neutron Position Sensing System

CAEN
Tools for Discovery

User Manual
UM11805

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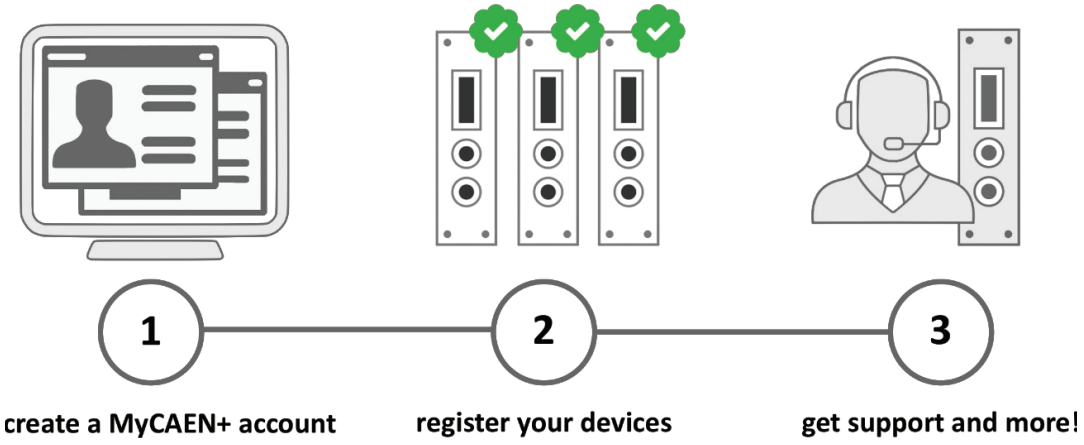

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Purpose of this Manual

The User Manual contains the full description of the Thanos DAQ software release **2025.4.24.1**, which is compliant with the firmware versions **NBRICK16-7030** and **NBRICK16-7035** of the NBrick Neutron Position Sensing system.

Change Document Record

Date	Revision	Changes
May 8th, 2025	0	Initial release.

Symbols, abbreviated terms and notation

HV	High Voltage
SHV	Safe High Voltage
DAQ	Data Acquisition
QDC	Charge-to-Digital converter
ADC	Analog-to-Digital Converter
DAC	Digital-to-Analog Converter
USB	Universal Serial Bus
OS	Operating System
ToF	Time of Flight
AC	Alternating Current
DHCP	Dynamic Host Configuration Protocol
ROI	Region Of Interest
LSB	Least Significant Bit

Reference Documents

[RD1] UM7222 - 803x Series Programmable HV Power Supply User Manual.

[RD2] DS8931 - R1443 Pre-amplifiers Data Sheet.

[RD3] UM6952 - R5560 Digitizers User Manual.

All CAEN documents can be downloaded at:
`www.caen.it/support-services/documentation-area`

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Limitation of Responsibility

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

Disclaimer

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

Made in Italy

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

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1 Introduction

The NBrick system is a modular data acquisition (DAQ) platform designed for neutron detection applications, integrating advanced hardware and firmware components for high-precision signal processing, charge integration, and real-time data analysis. It is optimized for use with position-sensitive neutron detectors, such as ^{3}He and BF_3 tubes, making it an essential tool in nuclear physics experiments, radiation monitoring, and neutron imaging applications.

The NBrick system consists of three key hardware components: a pre-amplifier, a digitizer, and a high-voltage power supply, all of which work together to ensure precise neutron detection and signal processing.

The R1443C Charge Sensitive Pre-Amplifier is a 32-channel module well suitable for the use with ^{3}He and BF_3 neutron detectors. It amplifies low-level signals and outputs them as differential signals through RJ45 connectors, ensuring compatibility with the digitizer included in this system.

Once amplified, signals are processed by the R5560C Digitizer, a 32-channel, 14-bit, 125 MS/s data acquisition unit. This module is equipped with RJ45 differential inputs and supports multiple communication interfaces, including USB 3.0, Ethernet, and Optical Link. Its onboard firmware is optimized for position reconstruction using Resistive Charge Division and performs real-time signal digitization, time tagging and charge integration. The integrated 2.4” touchscreen provides a convenient interface for quick configuration and status monitoring.

To supply high voltage to the detectors, the system includes the R8033DP High Voltage Power Supply, which provides 16 independent HV channels. Each channel can deliver up to 4 kV and 3 mA with adjustable ramp-up and ramp-down rates. The unit features advanced safety mechanisms, including overvoltage, undervoltage, overcurrent, and interlock protection, ensuring safe and stable operation in demanding experimental environments.

The entire system is managed through Thanos DAQ Software, a powerful interface that allows users to control the digitizer and high-voltage power supply remotely via Ethernet. Thanos provides comprehensive data acquisition tools, including real-time waveform visualization, energy spectrum analysis, and position reconstruction. It also includes oscilloscope functionalities, fitting tools, and advanced calibration options.

The NBrick QDC firmware is specifically designed for efficient neutron detection and signal processing. It continuously digitizes the 32 input signals from the pre-amplifier. Once a trigger is activated, the firmware generates a charge integration gate, during which the baseline remains frozen at its last averaged value, ensuring accurate energy measurement. The integrated charge, along with the event timestamp and waveform data, is then packaged and transmitted to Thanos software, where further processing and analysis are performed.

By integrating state-of-the-art digitizers, pre-amplifiers, and high-voltage power supplies, the NBrick system offers a scalable and flexible solution for neutron detection and advanced data acquisition. Its high-precision firmware, combined with real-time processing capabilities and the Thanos DAQ software, makes it a powerful tool for a wide range of nuclear physics experiments and industrial applications. Designed to meet the needs of scientists and engineers, NBrick provides an efficient, reliable, and fully integrated platform for modern neutron detection and data analysis.

Accessories	Description
HV Cables	High Voltage Cable Assemblies
SHV to HN Cables	AC402S0H002 - SHV to HN Male 4kV cable, 2mt
A148x	Inhibit - Kill Signal BNC Adapter for HV Power Supply Modules

Tab. 1.1: Table of related items.

2 Hardware Description

The CAEN NBrick is a rack-mount system designed for neutron detection applications. It consists of three main modules:

- R8033DP: a High Voltage board (16 channels up to +4 kV/3 mA).
- R1443C: a Charge Sensitive Preamplifier well suitable for $^{3}He/BF_3$ tubes (32 independent HV channels);
- R5560C: a 32-channels, 14-bit, 125 MS/s Pulse Processor.

These three units are integrated to form a complete readout system capable of supporting up to 16 position-sensing $^{3}He/BF_3$ tubes.

CAEN provides the **Thanos DAQ** software, which enables remote management of the High Voltage board and the Digitizer. The software allows users to acquire waveforms, energy spectra and Time-of-Flight (ToF) spectra, and to perform position reconstruction (see Chap. **4** or details).

2.1 R8033DP Programmable High Voltage Power Supply

Fig. 2.1: The R8033DP Programmable HV Power Supply.

The R8033DP module is a Programmable High Voltage (HV) Power Supply housed in a 19” rack unit, operating at 110/220 V AC. It provides 16 independent HV channels, each capable of providing +4 kV of maximum voltage and 3 mA of maximum current (up to 6 W).
HV outputs are delivered through SHV connectors. The RAMP-UP and RAMP-DOWN rates can be independently set for each channel within a 1÷500 V/s range, adjustable in 1 V/s steps. The module also features a 10 nA I_{SET} resolution.

The module can be controlled either locally via a 2.8” color Touchscreen LCD Display or remotely, via USB 2.0 or Ethernet connection.

The R8033DP includes multiple safety mechanisms:

- OVERVOLTAGE and UNDERVOLTAGE warnings: triggered when the output voltage differs by more than 2% from the set value (minimum 10 V).

- Programmable V_{MAX} and I_{MAX} protection limits: set via two separate front panel trimmers, applied at the same common value to all channels. V_{MAX} and I_{MAX} values can be read out via software.
- OVERCURRENT detection: if a channel tries to draw more current than its programmed limit, it enters TRIP status. The channel sustains the maximum allowed value for a programmable time (TRIP) before shutting down.
- Common Interlock logic for enabling/disabling channels, and individual KILL inputs signal for emergency shutdown of specific channels.

Note: For further details, please refer to the 803x Series Power Supply User Manual **[RD1]**.

2.2 R1443C Charge Sensitive Pre-amplifier

Fig. 2.2: The R1443C Charge Sensitive Pre-amplifier.

The R1443C module is a 32-channel Charge Sensitive Pre-amplifier housed in a 19" rack unit, well suitable for operating with neutron detectors as ^{3}He and BF_3 tubes. Thanks to its high channel density, it can handle up to 16 position-sensitive tubes, each featuring two readout outputs (one per end).
The pre-amplifier has an exponential time constant of 1 µs, that ensures optimal performance even at high rates exceeding 100 kspc. The module has a total gain of 2.25 V/pC (preamp = 1 V/pC + 2nd gain stage = 2.25 V/pC, customizable) and it is 120/230 V 50/60 Hz AC powered.

The outputs of the preamplifier, provided via RJ45 connectors, are differential signals. These signals are typically processed by Digital Pulse Processing electronics, in order to perform specific filtering to achieve the best charge, timing and axial position measurements.

Note: For further details, please refer to the R1443 Pre-amplifiers Data Sheet **[RD2]**.

2.3 R5560C Digitizer

The R5560C is a 19" rack-mount digitizer featuring 32 channels, 14 bit resolution and 125 MS/s sampling rate. It supports Differential analog inputs via RJ45 connectors and is designed for programmable data processing in high-preformance applications.

Fig. 2.3: The R5560C Digitizer.

The onboard firmware performs Resistive Charge Division for position reconstruction and outputs energy/timing data (see Chap. **3**).

Well suitable for the readout of position-sensitive ^{3}He tubes in combination with R1443 preamplifier, it can be controlled by USB3.0, Ethernet, and Optical Link (OPTIONAL), to support remote management as well as extreme fast data flow. It also features a 2.4" touch screen display for quick configuration and status control.

The digitizer is capable to manage simultaneously digital and analog signals to implement many functionalities required by physics experiments: signal digitization, complex trigger logic, Pulse Height Analysis with MCA capabilities, Time Tagging, Pulse Shape Discrimination (PSD), Scaler, Counters and so on.

Note: For more details, please refer to the R5560 Digitizers User Manual **[RD3]**.

Note: For firmware upgrades specifically designed for Nbrick Neutron Sensing Position System, see Sec. **5**.

Note: The Digitizer R5560C features an input range of 2 V, spanning from -1 V to +1 V. However, it does not support the addition of an analog offset to shift the input signal within this range. As a result, the effective input dynamic range of the NBrick system is limited to 1V, specifically from 0 V to +1 V, since the firmware accepts only positive signals.

2.4 Packaging and compliancy

All the units are inspected by CAEN before the shipment, and it is guaranteed to leave the factory free of mechanical or electrical defects.

When receiving the units, the user is strictly recommended to inspect for any damage which may have occurred during transportation. Particularly, inspect for exterior damages like broken connectors and check that the panel is not scratched or cracked.

All packing material should be held on until the inspection has been completed. If damage is detected, the user must file a claim with the carrier immediately and notify CAEN.

Before installing the units, make sure to read thoroughly the safety rules and installation requirements, then place the package content onto your bench.

The content of the delivered package standardly consists of the part list shown in the table below (see Tab. **2.1**). All the official documentation, firmware updates, software tools, and accessories are available on *https:/www.caen.it* at the products web pages.

CAUTION: to manage the product, consult the operating instructions provided.

When receiving the unit, the user is strictly recommended to:

- Inspect containers for damage during shipment. Report any damage to the freight carrier for possible insurance claims.
- Check that all the components received match those listed on the enclosed packing list as in Tab. **2.1**. (CAEN cannot accept responsibility for missing items unless we are promptly notified of any discrepancies.)
- Open shipping containers; be careful not to damage contents.
- Inspect contents and report any damage. The inspection should confirm that there is no exterior damage to the unit such as broken knobs or connectors and that the front panel and display face are not scratched or cracked. Keep all packing material until the inspection has been completed.
- If damage is detected, file a claim with carrier immediately and notify CAEN service (see Chap. **9**).
- If equipment must be returned for any reason, carefully repack equipment in the original shipping container with original packing materials, if possible. Please contact CAEN service.
- If equipment is to be installed later, place equipment in original shipping container and store in a safe place until ready to install.

DO NOT SUBJECT THE ITEM TO UNDUE SHOCK OF VIBRATIONS

DO NOT BUMP, DROP OR SLIDE SHIPPING CONTAINERS

DO NOT LEAVE ITEMS OR SHIPPING CONTAINERS UNSUPERVISED IN AREAS WHERE UNTRAINED PERSONNEL MAY MISHANDLE THE ITEMS

USE ONLY ACCESSORIES WICH MEET THE MANUFACTURER SPECIFICATIONS

Note: For a correct and safe use of the module, please refer to "Power Requirements" Chapter and "Cooling Management" Chapter in the User Manual of the specific module **[RD1][RD2][RD3]**.

	Part	Description	Qt
	R8033DP	Programmable HV Power Supply	x1
	R1443C	Charge Sensitive Pre-amplifier	x1
	R5560C	128 Ch 14 bit 125 MS/s Digitizer	x1
	SHV cables	SHV to SHV 6kV cable, 1mt	x16
	SHV cables	SHV to SHV 6kV cable, 2mt	x32
	Ethernet cable	ETHERNET CAT6 cable L=2MT	x8
	Documentation	UM7222 - R8033DP HV Power Supply User Manual	x1
	Documentation	DS8931 - R1443 Pre-amplifier Data Sheet	x1
	Documentation	UM6952 - R5560 Digitizer User Manual	x1

Tab. 2.1: Delivered NBrick kit content.

2.5 Hardware Installation

Follow these steps to properly install and configure all devices in a 19-inch rack:

1. Ensure you have the appropriate bolts for securing the devices in the rack (**bolts are not included**).
2. Verify the rack provides sufficient ventilation to prevent overheating.
3. Carefully slide the boards into the 19-inch rack.
   Take care to avoid placing the R5560C and the R1443C too close to each other. The recommended configuration is to position the R8033DP between the R5560C and R1443C, maintaining a slight distance between the preamplifier and the other two units (Fig. **2.4**).
4. Secure each device using the locking bolts.
5. Connect the R5560C, R1443C and R8033DP to the main power supply.
6. Use SHV cables to connect the HV output channels of the R8033DP to the HV IN channels of the R1443C on the front panel (Fig. **2.4**).
7. Use SHV cables to connect the detector to the Detector In SHV channels on the rear panel of the R1443C (Fig. **2.5**).
8. Use Ethernet cables to connect the R1443C preamplifier output channels to the CH1...32 Input channels of the R5560C (Fig. **2.4**).
9. Power on the R8033DP, the R5560C and the R1443C.
10. On the R8033DP front panel display, press the power supply icon and set the Control Mode to Remote (if not already set).
11. Set all the R8033DP channel switches into the ON/EN position.
12. Connect both the R8033DP and the R5560C to the DAQ PC via Ethernet. It is suggested to use a small Ethernet switch.

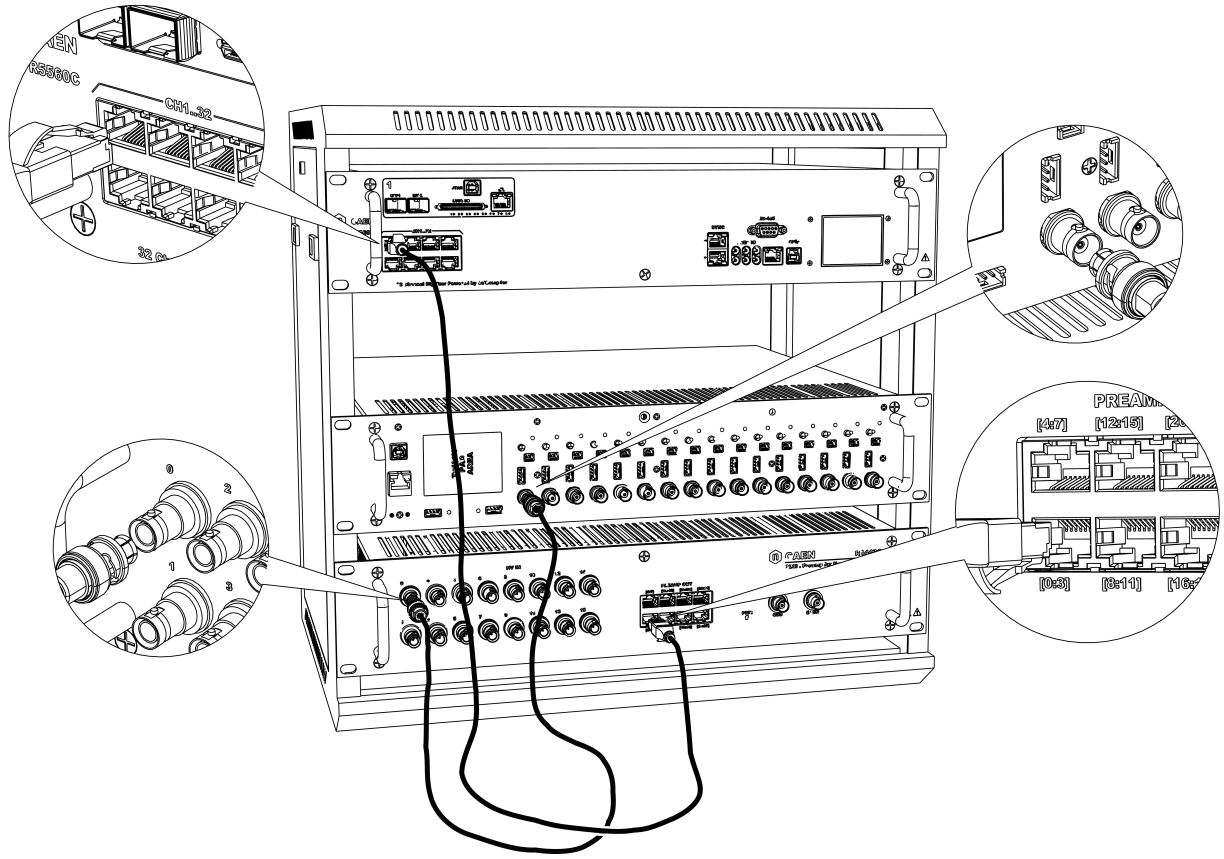


Fig. 2.4: NBrick front cables connection.

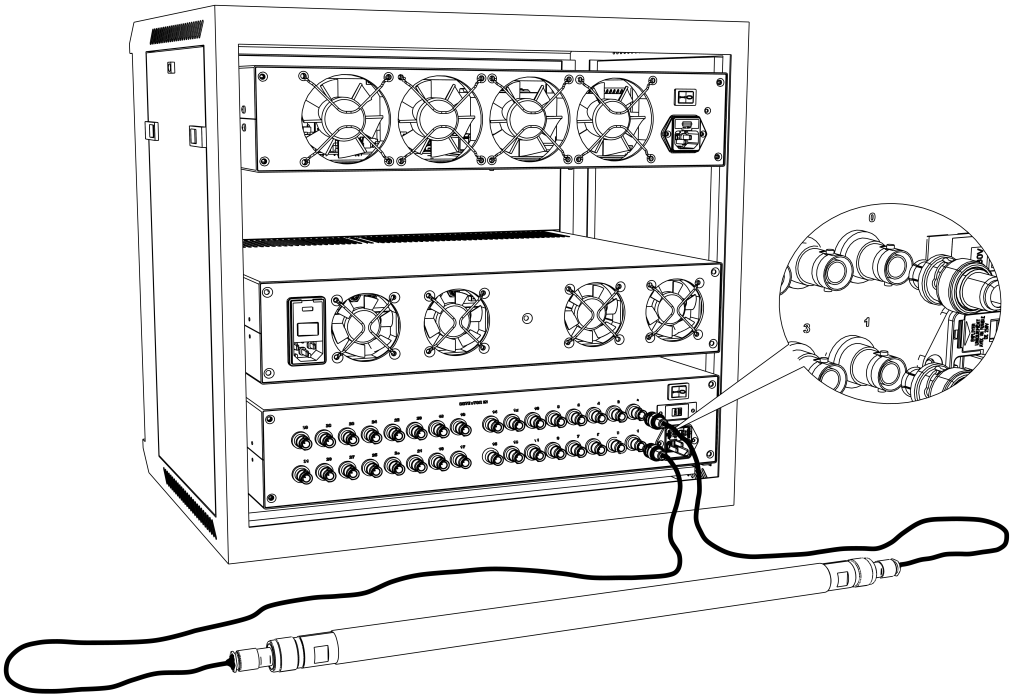


Fig. 2.5: NBrick back cables connection.

3 Multichannel Charge Integration: QDC Firmware

The NBrick QDC firmware is designed to handle real-time neutron detection by continuously digitizing and processing signals from 32 input channels. Its primary functions include signal reception, noise filtering, baseline correction, trigger processing, charge integration, and data transmission to the Thanos DAQ software. The firmware ensures accurate event detection and energy measurement by applying dynamic range adjustments, trigger logic, and integration techniques. User-configurable settings allow for precise adjustment based on the experimental requirements.

3.1 Principle of operation

Fig. **3.1** shows the functional block diagram of the NBrick QDC firmware.

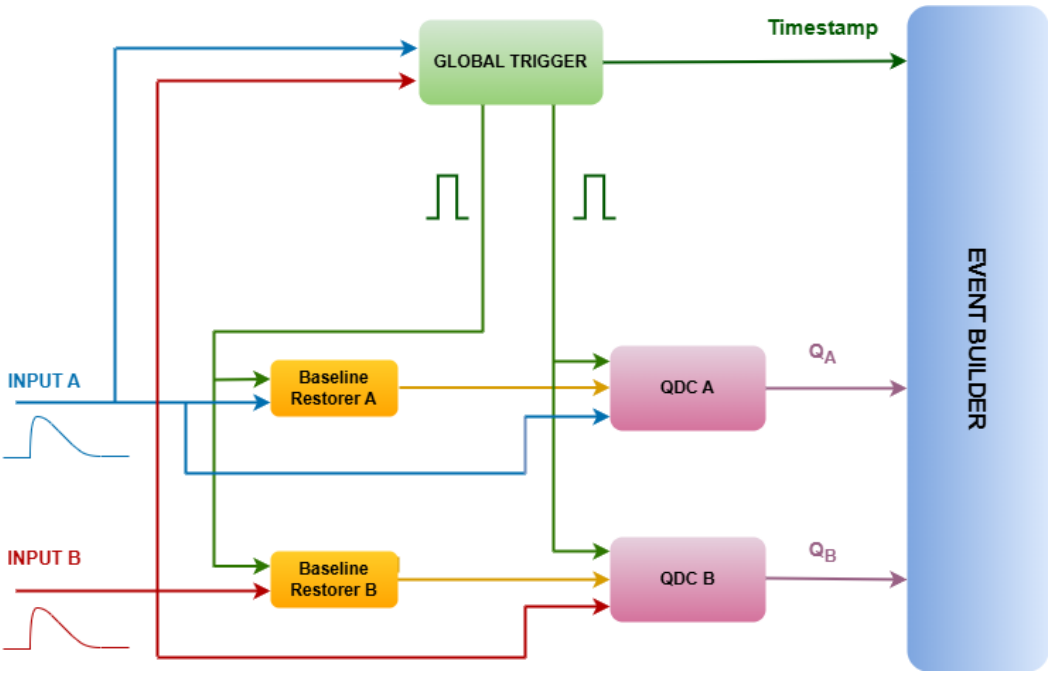


Fig. 3.1: Functional Block Diagram of the NBrick QDC Firmware.

The two input signals from each detector tube are routed to two parallel processing blocks:

1. **Global Trigger Logic**: in the first branch, the signals are processed by the Global Trigger, which applies a logic operation — AND, OR, or SUM (A+B) — depending on the user's selected trigger mode (Fig. **3.2**). This block generates a Global Trigger signal along with a timestamp marking the occurrence of the event.
2. **Baseline Restoration and Charge Integration**: simultaneously, the second branch performs baseline restoration for both input signals. The restored signals are then sent to the **QDC** (Charge-to-Digital Converter) block, where charge integration is carried out to determine the energy associated with each signal.

Finally, the timestamp and the two integrated energy values are forwarded to the Event Builder, which compiles and stores the event data for further analysis.

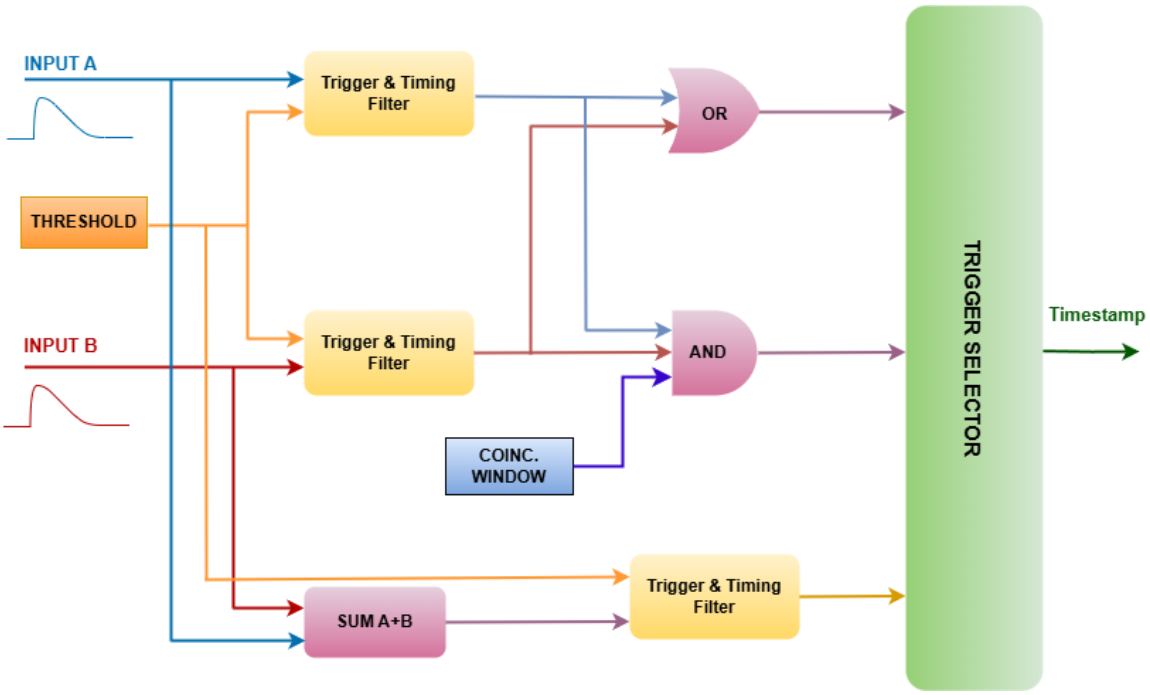


Fig. 3.2: Functional Block Diagram of the Global Trigger stage.

The QDC firmware performs the following main operations:

- Receives 32 input signals from the pre-amplifier outputs and continuously digitizes them. The dinamic range can be adjusted using a programmable DC offset to exploit the full dinamics of the digitizer; the DC offset is applied globally to all channels. The digitizer accepts only positive signals, if the input polarity is set to negative, the firmware inverts the signal.
- A ”Noise filter” stage processes the signals using a moving average filter with a programmable window length. The window length can be set in nanoseconds (ns) and applies globally to all channels.
- The algorithm cointinuously calculates the signal baseline by averaging input samples within a moving window of programmable size (more details in Sec. **3.1.1**). Once determined, the baseline remains frozen during the baseline hold-off duration.
- The input signals coming from the two ends of each tube are processed according to the selected trigger mode (more details in Sec. **3.1.2**). The firmware then compares the resulting signals to a user-defined trigger threshold, which can be configured individually for each tube.
- Once a trigger is detected, the firmware initiates the charge integration process and opens a charge integration gate. A ”Pre-gate” window can be set globally to start the charge integration before the trigger signal and so cover the whole input signal duration. While the gate is active, the baseline remains frozen at its last averaged value and its value is used as a charge integration reference. The ”Gate width” is a global setting.
- A ”Fine gain” can be set individually for each channel via software, allowing users to scale the charge integration results for energy calibration. This multiplicative factor, adjustable between 0 and 1, ensures that all channels contribute consistently to the final energy spectrum. (more details in Sec. **3.1.3**).
- During the programmable ”trigger hold-off” duration, additional triggers are inhibited to prevent overlapping events. It is recommended to set the hold-off duration based on the typical signal width to avoid unnecessary retriggering.

- The trigger enables the event building, which includes the waveforms, the trigger timestamp, the baseline and the charge integrated within the gate. After processing, the system is ready for the next event.
- The processed data from each tube end is wrapped and sent to the Thanos software, where it is unpacked and used for position reconstruction, energy spectrum analysis, and advanced visualization. The software calculates the center of mass of the integrated charges using the following formula:

$$\frac{Q_A}{Q_A + Q_B} \cdot N_{bin} \tag{3.1}$$

  where:
  - Q_A and Q_B are the integrated charges collected from the two ends of the detector tube;
  - N_{bin} is the number of bins selected from the GUI to define the resolution of the spectrum.

3.1.1 Baseline

The baseline calculation is a critical feature of the QDC firmware, since its value serves as a reference level for charge integration. Users can configure the number of samples used by the firmware to evaluate the baseline average value through the ”Baseline Mode” setting (Sec. **4.2.5**). Once the baseline value is computed, it is frozen for a duration specified by the ”Baseline Hold-Off” parameter, starting from the pre-gate. These settings apply globally to all channels.

3.1.2 Trigger Management

The firmware allows users to configure how signals from the two ends of each detector tube interact to generate a trigger. There are three available trigger modes:

- **OR**: A trigger signal is generated when either of the two signals exceeds the threshold.
- **AND**: A trigger occurs only if both signals exceed the threshold value within a user-defined ”Coincidence window”.
- **A+B**: A trigger is produced when the sum of both signals goes over threshold.

The trigger type is a global setting, meaning all tubes operate under the same trigger logic. The threshold value can be decided individually for each tube and is relative to the baseline. Users can enable or disable specific tubes using the ”Trigger Mask”, selecting which detectors actively contribute to the triggering process. Additionally, the ”Trigger Hold-Off” parameter defines the time interval before a new trigger can be generated, preventing retriggering and optimizing acquisition stability.

3.1.3 Fine Gain

The ”Fine Gain” is a multiplicative factor applied to the integrated charge, that allows users to fine-tune the energy spectrum binning across different channels. It can be set individually for each channel (32 channels in total) and its accettable range is 0 to 1. Further details and application examples are available in Sec. **4.2.5**.

3.1.4 Noise Filter

To enhance signal quality, the firmware integrates a ”Noise Filter”, which applies a moving average algorithm that smooth out rapid fluctuations in the input signals. This filtering process helps improve signal stability and enhances the accuracy of charge integration. The filter operates by replacing each input sample with the mean value of all samples within the filter window. The window width is user-configurable

and can be selected from a set of fixed values (Sec. **4.2.5**). Charge integration can be performed on the raw input samples or on the filtered samples, depending on the Noise filter whether is enabled or not. This feature can be disabled from Thanos settings.

4 Thanos DAQ Software

The **Thanos** DAQ software is an application designed to manage remote communication with the High Voltage Power Supply (R8033DP) and the R5560C Digitizer, while also handling data acquisition from the CAEN NBrick system. The software enables users to configure system settings, acquire and visualize waveforms, analyze energy and ToF spectra, perform position reconstruction and save data and plots for further analysis, as it will be described in Sec. **4.2**

The R5560C and the R8033DP do not require any additional driver to operate with Ethernet link and they are compatible with any OS.

4.1 Thanos Installation

CAEN provides the full installation package for the Thanos software in a standalone version for Windows OS. This version installs all the binary files and required libraries.

1. Download the Thanos software from CAEN Website.
2. Run the executable *"Thanos for Caen NBRICK-setup-2025.4.24.1"* and the Setup Wizard will guide you troughout the installation procedure, as shown in the following.

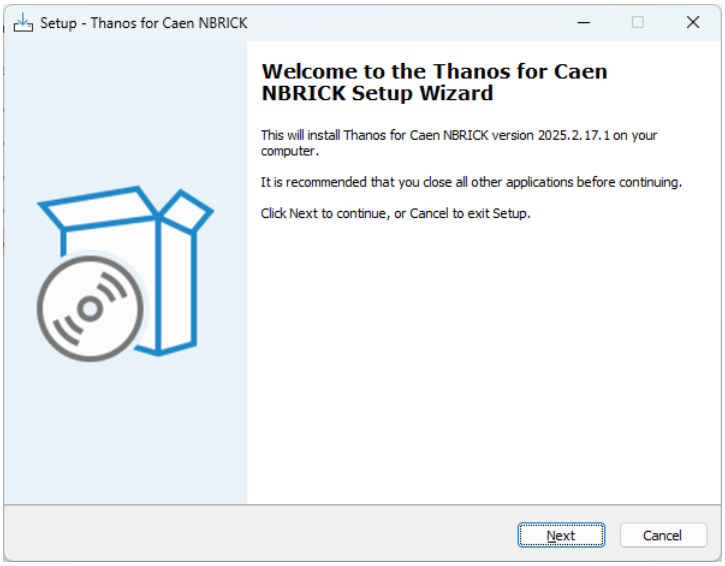


Fig. 4.1: Thanos Wizard Dialog Box - Start Installation.

For the Thanos installation path, the user must accept the default directory, which is set to: C:\Thanos\2025.4.24.1. Additionally, administrator privileges are required to complete the installation process successfully.

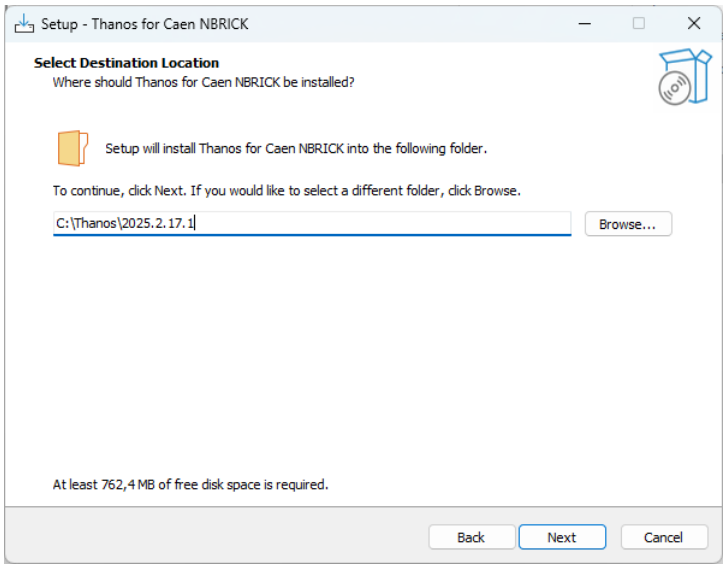


Fig. 4.2: Thanos Wizard Dialog Box - Installation path selection.

Press "*Browse*" if you want to change it with a different path, but it is not recommended.

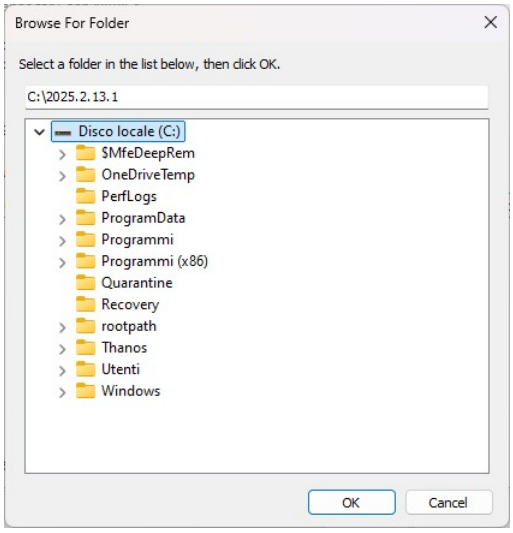


Fig. 4.3: Thanos Wizard Dialog Box - Installation path change window.

If the selected installation folder already exists, Thanos does ask the user for the overwrite confirmation.

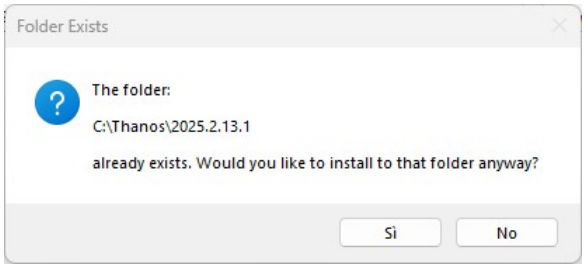


Fig. 4.4: Thanos Wizard Dialog Box - Installation folder overwrite confirmation.

Thanos allows to choose the Start Menu folder where the Setup will create the program's shortcut. By default the folder "Nuclear Instruments" is proposed.

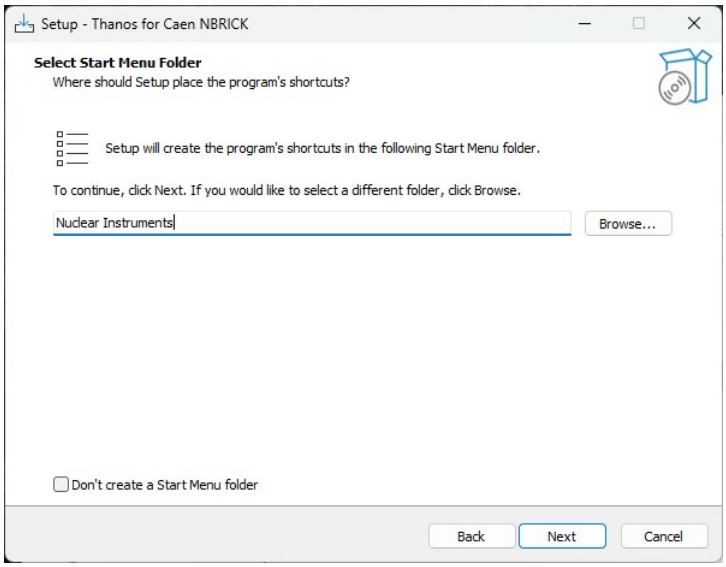


Fig. 4.5: Thanos Wizard Dialog Box - Program's shortcut.

Press "*Browse*" if you want to change it with a different folder.

Optionally, mark the checkbox labelled "**Don't create a Start Menu folder**" to not create a Thanos shortcut in a Start Menu folder. Then left click on "*Next*" to continue.

Check the installation setting summary window and press "*Install*" when ready to install the Thanos software.

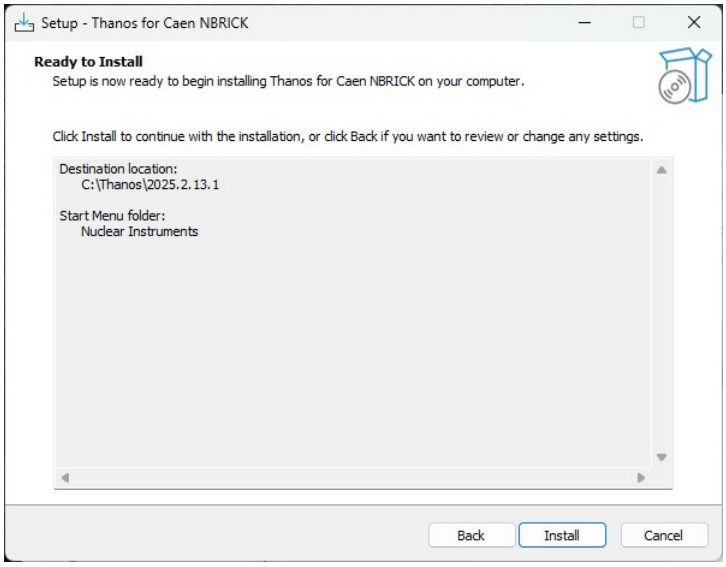


Fig. 4.6: Thanos Wizard Dialog Box - Installation.

The Thanos Setup Wizard will check for any existing Thanos installation on the system. If a previous version is found, the wizard will ask the user to first uninstall it before proceeding. The uninstallation process will be handled automatically.

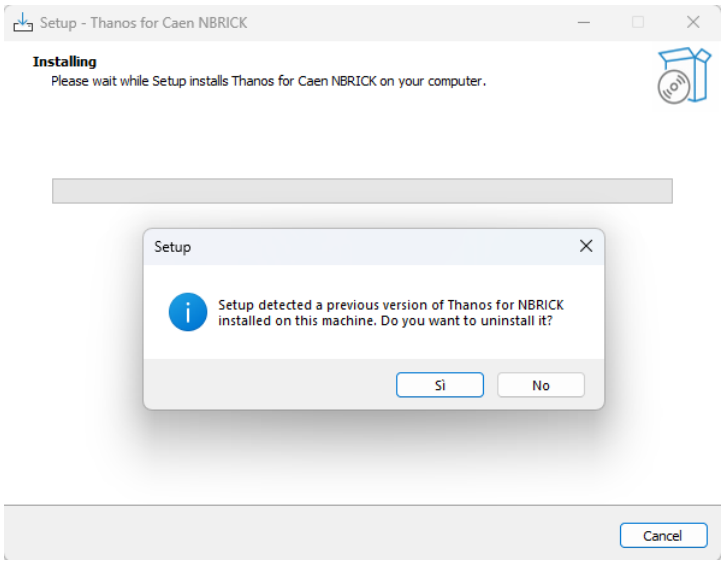


Fig. 4.7: Thanos Wizard Dialog Box - Detection of previous installation.

Click "*Yes*" to proceed with the old Thanos version uninstall.

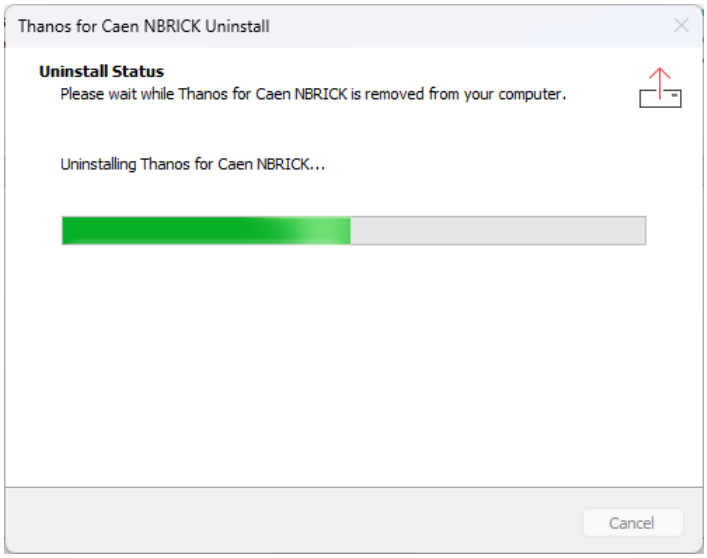


Fig. 4.8: Thanos Wizard Dialog Box - Uninstallation progress.

Then Thanos Setup Wizard will extract and install the relevant files.

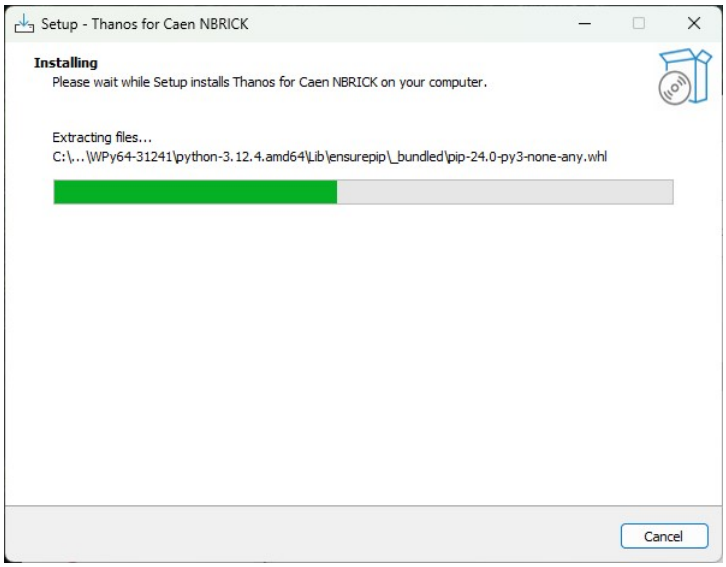


Fig. 4.9: Thanos Wizard Dialog Box - Installation progress.

If a previous version of ”CAENHVWrapper” is installed, the software Setup will ask the user to uninstall it before installing the new version.

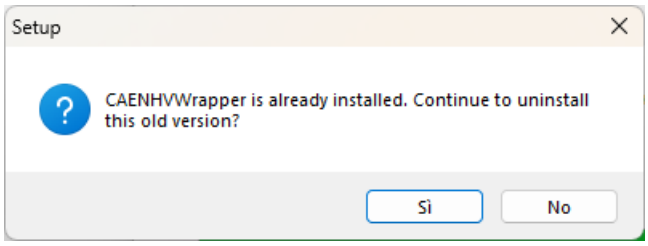


Fig. 4.10: Thanos Wizard Dialog Box - Detection of previous CAENHVWrapper.

Click ”*Yes*” to proceed with the update.

At the end of the installation, the following Dialog Box will appear:

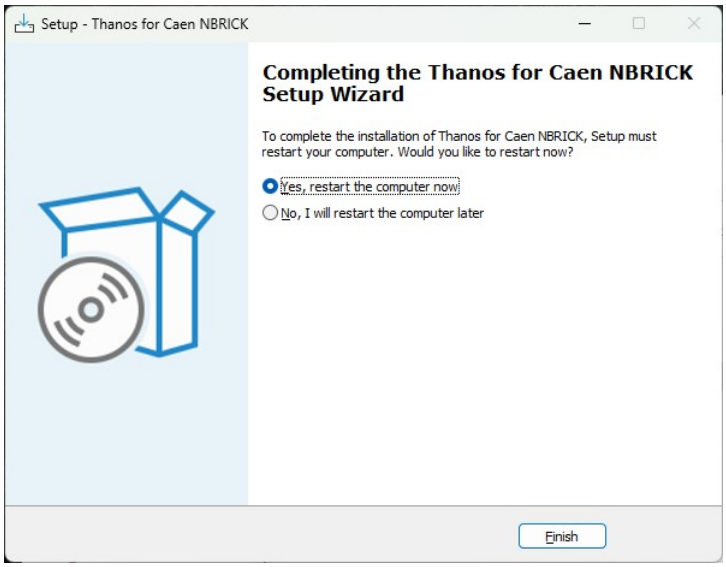


Fig. 4.11: Thanos Wizard Dialog Box - Restart request to complete the installation.

To complete the Thanos Installation it is reccommend to mark the checkbox labelled "**Yes, restart the computer now**". Then left click on "*Finish*".

4.2 GUI description

When the Thanos software is launched (in case some privilege-related errors occur, start Thanos with the Administrator privileges), the following start window is displayed:

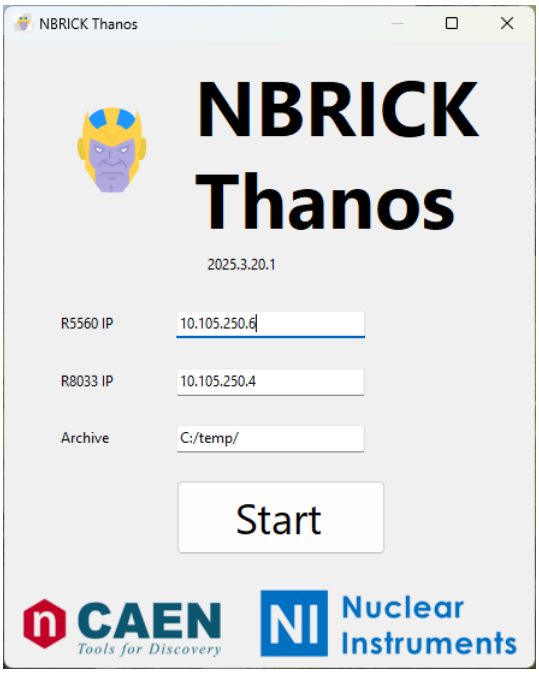


Fig. 4.12: Thanos Start window.

The numbers displayed below the title represent the software version. To communicate with the R5560C Digitizer and the R8033 HV Power Supply, the Thanos software requires an Ethernet connection to both devices. For this purpose enter the IP address of the R5560C and R8033DP in the designated fields. Then press "*Start*" button to launch the Thanos GUI and provide the required authorization to the firewall to allow the processes to operate. Once connected, the software will allow system configuration and data acquisition.

Note: As described in previous chapters, the R1443C Pre-Amplifier outputs up to 32 signals, allowing the connection of up to 16 detector tubes. To maintain consistency in the Thanos software, the following naming conventions are used:

- **Channel** A_n and **Channel** B_n represent the analog signals from the two ends of each tube (n = 0,..., 32).
- **Tube n** represents a pair of signals corresponding to a single detector tube (n = 0,...,15).

These conventions are used throughtout the following sections to describe signal processing and data acquisition. The correspondance is shown in Tab. **4.1**.

Channels A_n/B_n	Corresponding Tube number
A0/B0	Tube 0
A1/B1	Tube 1
A2/B2	Tube 2
A3/B3	Tube 3
A4/B4	Tube 4
A5/B5	Tube 5
A6/B6	Tube 6
A7/B7	Tube 7
A8/B8	Tube 8
A9/B9	Tube 9
A10/B10	Tube 10
A11/B11	Tube 11
A12/B12	Tube 12
A13/B13	Tube 13
A14/B14	Tube 14
A15/B15	Tube 15
A16/B16	Tube 16

Tab. 4.1: Correspondence between pre-amplifier channels and detector tubes.

Note: The Digitizer R5560C features an input range of 2 V, spanning from -1 V to +1 V. However, it does not support the addition of an analog offset to shift the input signal within this range. As a result, the effective input dynamic range of the NBrick system is limited to 1V, specifically from 0 V to +1 V, since the firmware accepts only positive signals. .

Software starts on the ”Browser” window. In the upper-left corner, there are two additional tabs named ”Qt Server” and ”Python Server” (described in Sec. **4.2.7**).

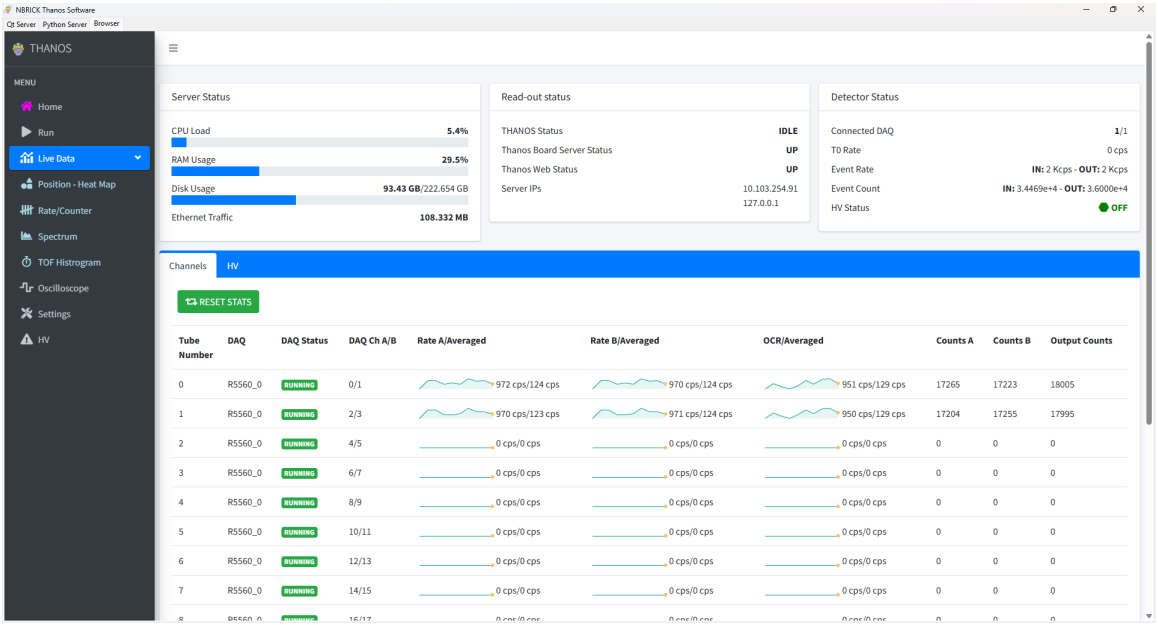


Fig. 4.13: Thanos Home tab.

On the left side of the interface, a navigation panel provides access to various tabs each corresponding to a specific feature of the software (Fig. **4.14**). These features will be described in detail in the following sections.

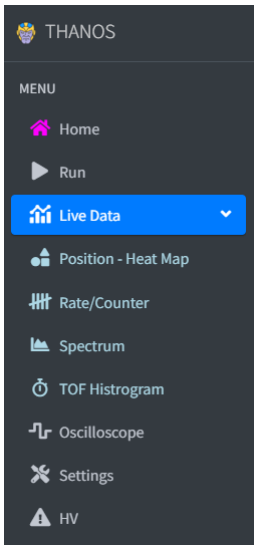
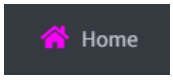


Fig. 4.14: Thanos Browser Main Bar.

Clicking on button in the upper-left corner of the window is possible to toggle visible/invisible the Thanos Main Bar.

4.2.1 Home tab



The "Home" tab is the starting window of the Thanos software (Fig. **4.13**). It provides a real-time overview of the system status through three main panels: the Server Status, the Read-out Status and the Detector Status.

The Server Status panel (Fig. **4.15**) displays the CPU Load and the RAM Usage expressed in percentage, the Disk Usage and the Ethernet Traffic expressed in GBytes. These parameters mainly indicate the impact of the software on the PC performance and network connections.

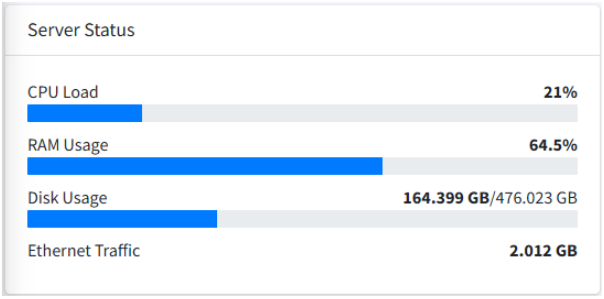


Fig. 4.15: Thanos Server Status Panel.

The Read-out Status panel (Fig. **4.16**) shows the status of Thanos, Thanos board Server and Thanos Web. In the last row is possible to read the IP address of the connected servers.

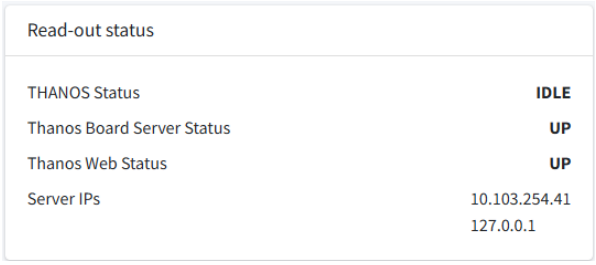


Fig. 4.16: Thanos Read-out Status Panel.

The Detector Status panel (Fig. **4.17**) provides real-time detector status, including the number of DAQs connected, the T_0 signal rate expressed in cps (counts per second), the total Event rate in INPUT/OUTPUT expressed in cps, the Event count in INPUT/OUTPUT, and the HV Status (ON/OFF).

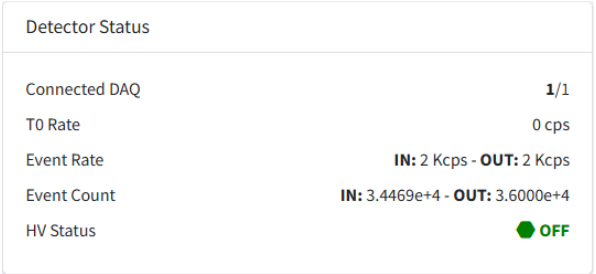


Fig. 4.17: Thanos Detector Status Panel.

In the lower section of the window, two dashboards allow users to monitor the Channels and the HV status. Additionally, a green button (Fig. **4.18**) allows to reset the statistics displayed in the monitoring panels.

Fig. 4.18: Thanos Reset Statistics button.

The ”Channels” dashboard displays ten columns:

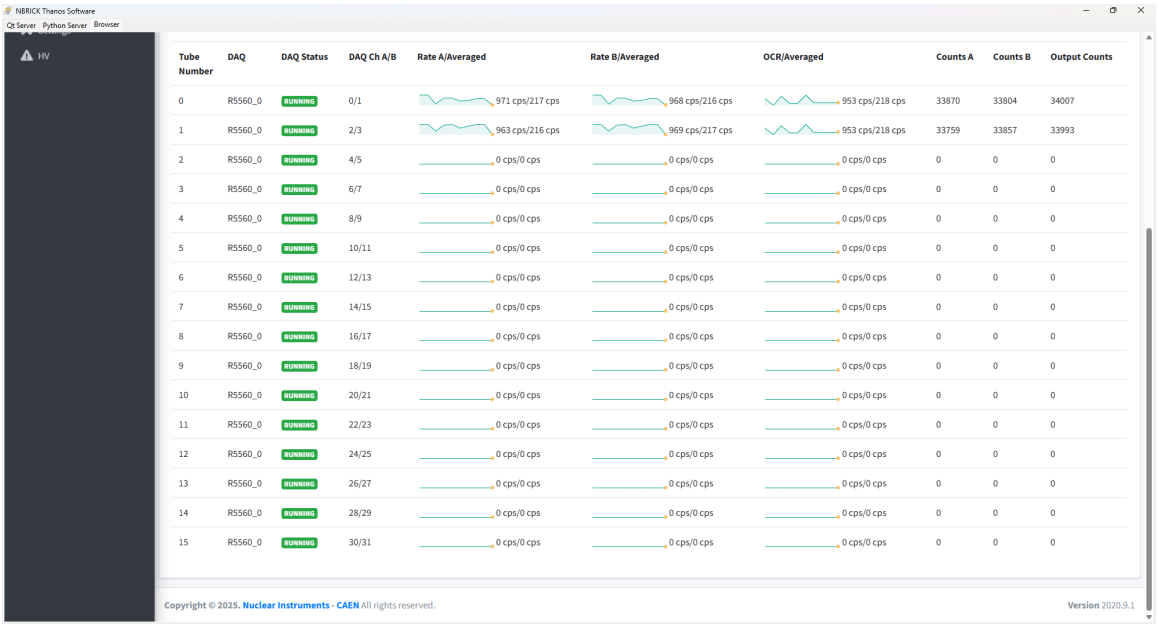


Fig. 4.19: Thanos Channels dashboard example.

- **Tube Number**: identifies the number of the detector tube connected to the NBrick system.
- **DAQ**: identifies the DAQ module of the R5560C Digitizer.
- **DAQ Status**: displays the current status of the DAQ. The ”RUNNING” state indicates that the system is actively acquiring signals and is fully operational.
- **DAQ Ch A/B**: indicates the DAQ channels connected to the two ends of the tube.
- **Rate A/Averaged**: shows the event rate for the first channel of the tube and its average rate, respectively.
- **Rate B/Averaged**: shows the event rate for the second channel of the tube and its average rate, respectively.
- **OCR/Averaged**: shows the Output Count Rate of the tube and its average value, respectively.
- **Counts A**: displays the total event count on the first channel of the tube.
- **Counts B**: displays the total event count on the second channel of the tube.
- **Output Counts**: displays the total output event count of the tube.

The ”HV” dashboard displays six columns, providing details on the High Voltage system:

- **HV Board**: identifies the HV board connected to the NBrick system.
- **HV Status**: displays the current status of the HV board. The ”READY” state indicates that the board is powered on and fully operational.

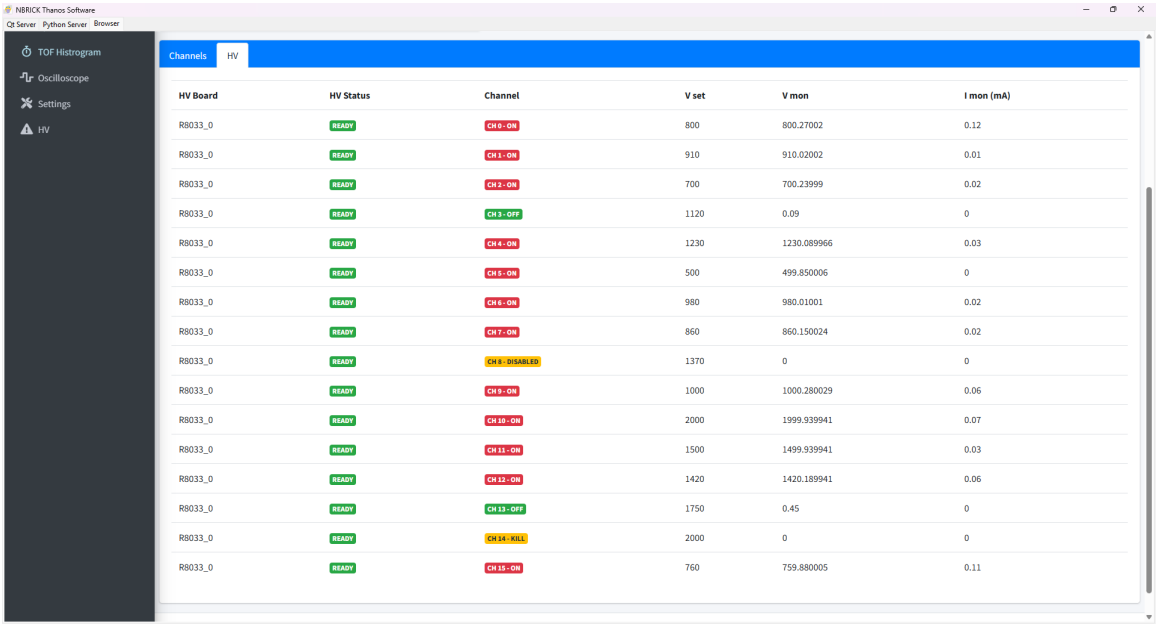
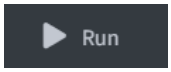


Fig. 4.20: Thanos HV dashboard example.

- **Channel**: shows the current status of each HV Channel (see. Tab. **4.2**).
- V_{set}: shows the set voltage.
- V_{mon}: shows the measured voltage in real time.
- I_{mon} **(mA)**: shows the measured current in real time.

4.2.2 Run tab



The ”Run” tab provides tools for managing and monitoring data acquisition runs. It consists of two main dashboards.

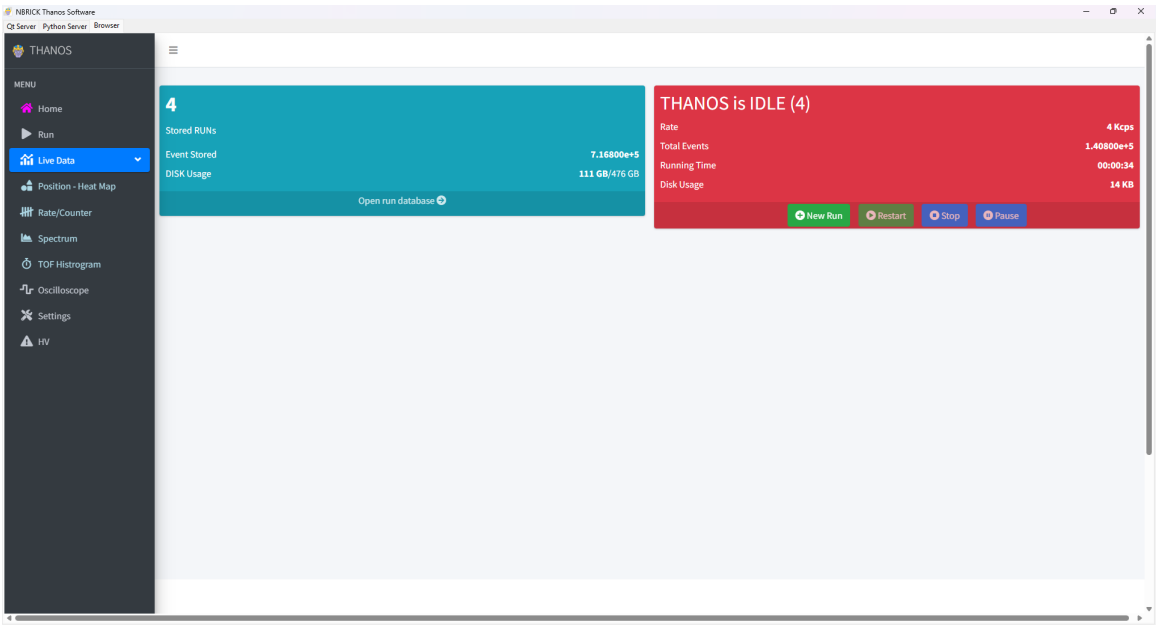


Fig. 4.21: Thanos Run tab.

The first panel displays a list of stored runs in the database. It includes information on the number of events stored and the Disk space used.
To access the database, click on ”*Open run database*”.

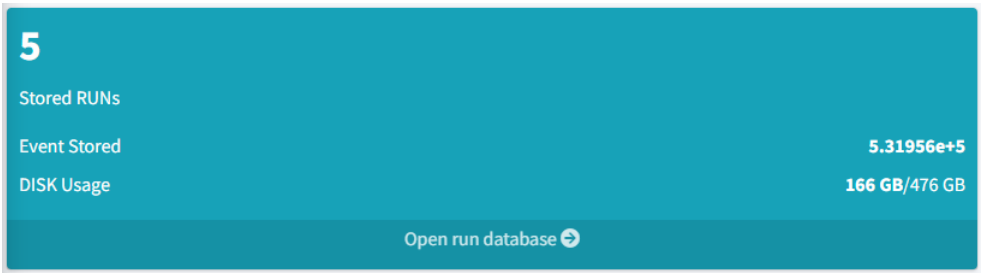


Fig. 4.22: Thanos Run database first panel.

Once opened (Fig. **4.23**), each row represents a saved run, characterized by:

- **Id**: identification number of the run.
- **Machine Id**: identification number of the machine.
- **Operator**: name of the operator who performed the measurement.
- **Run Type**: a label to identify the type of run.
- **Param 0,...,3**: custom parameters that the operator can define to differentiate runs.
- **Start date**: the date and time the run began.
- **Running Time**: the elapsed time since the run started.

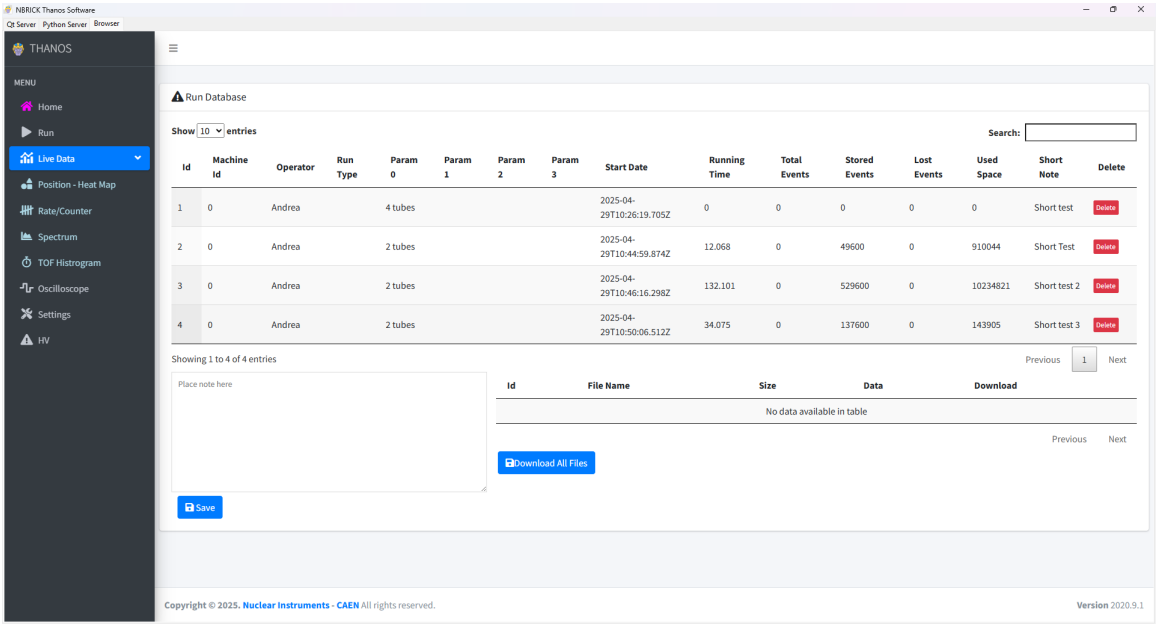


Fig. 4.23: Thanos Run database window.

- **Total Events**: the total number of detected events.
- **Stored Events**: the total number of events stored.
- **Lost Events**: the number of events lost during the acquisition.
- **Used Space**: the memory space allocated for storing the run.
- **Short Note**: a useful note for the users that can be added to the run.
- **Delete**: a button to delete the run from the database.

At the bottom of the window there are two panels: a notes panel, which allows users to associate short notes to a selected run and a download panel to retrieve stored data files for further analysis (Fig. **4.24**). Users can select individual file for download or save all available files (from a specific run) at once pressing the "*Download All Files*" button.

Three types of files are generated and stored during a run:

1. **Oscilloscope data file**: a file named "oscilloscope_0_0", containing waveform data recorded from all enabled channels during oscilloscope acquisition. This saving option, along with its configuration parameters, can be enabled from the "Setting" tab under "Acquisition" panel in the "Processing" folder (see Sec. **4.2.5.2**).
2. **Dumper Data files**: named "dumper_0_**n**", where "**n**" is an increasing index. Each file stores a numer of data rows, selectable from the "Setting" tab under "Acquisition" option in the "Processing" folder. When this limit is exceeded, a new file is created and the "**n**" index is incremented (see Sec. **4.2.5.2**). Each Dumper file includes essential acquisition data such as: the timestamp of the event, the channel from which the event was acquired, the raw energy value of the event.
3. **Dumper Statistics files**: named "dumper_0_**n**.stat", a new **.stat** file is generated for each corresponding "dumper" file. It provides cumulative information about the acquisition process: the elapsed time from the start run, the total number of detected event recording up to the saving moment, the total event rate calculated over the elapsed time and the disk space used expressed in byte.
4. **Rate/Counter data file**: a file named "rate_counters_sink0_0" is generated (as saving option in "Acquisitions" panel, see Sec. **4.2.5.2**) to store rate and counts information for further analysis. This file includes the following data (with **n** ranging from 0 to 31, corresponding to the channels):

- **timestamp**: the exact time at which the cumulative data is saved.
- **rate_in_ch_n**: input event rate for channel **n**.
- **rate_in_T0**: input event rate of the T_0 reference signal.
- **rate_out_ch_n**: output event rate for channel **n**.
- **counts_in_ch_n**: total number of input events (counts) detected on channel **n**.
- **counts_in_T0**: total number of input events detected from the T_0 reference signal.
- **counts_out_ch_n**: total number of output events (counts) for channel **n**.

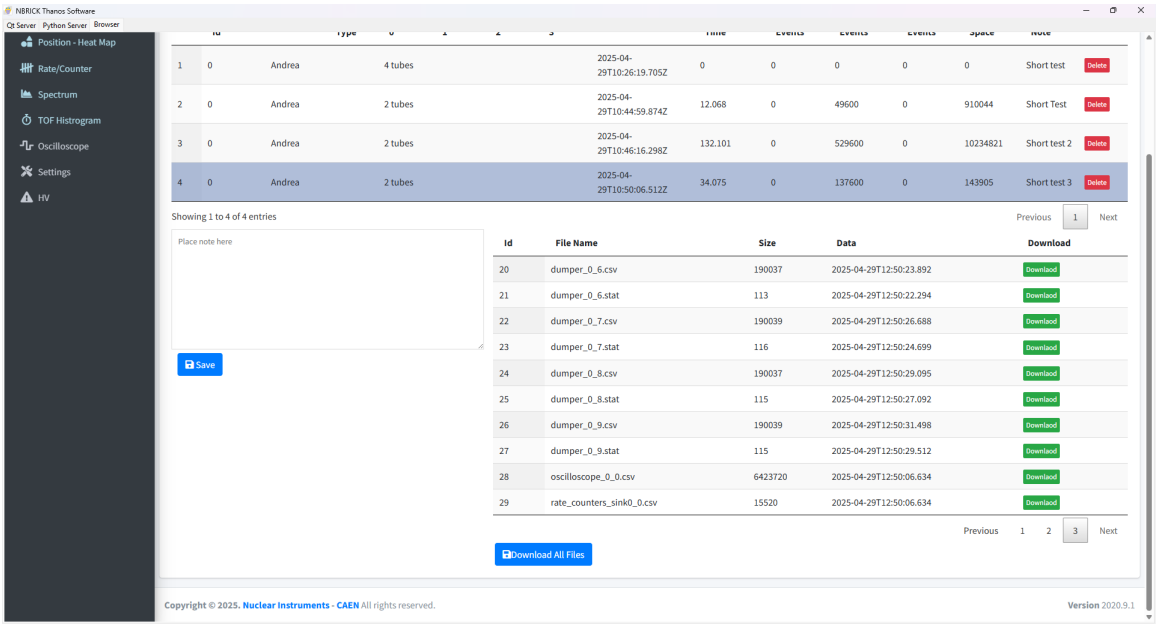


Fig. 4.24: Thanos Run data files.

The second panel of the ”Run” windows (Fig. **4.25**) displays the real-time status of the Thanos software, the total acquisition Rate (expressed in cps), the Total Events detected, the elapsed Running time and the Disk Usage for data storage. From this panel, the user can start and characterize a new run, restart, stop and pause a run.

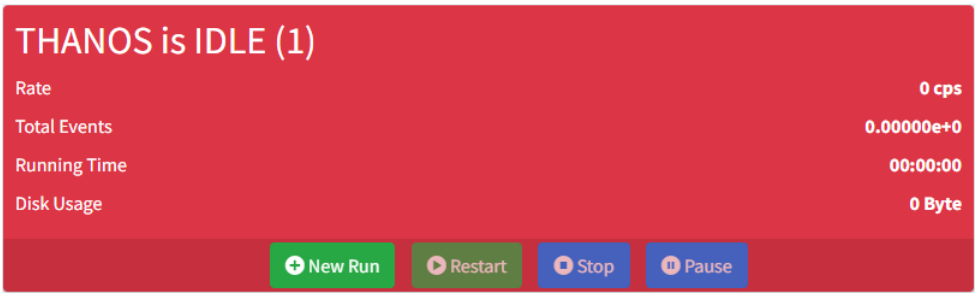


Fig. 4.25: Thanos Run database second panel.

Specifically, press on ”*New Run*” button to open a setup window (Fig. **4.26**) where the run parameters can be defined:

- **RUN ID**: identification number of the run.
- **Machine RUN Id**: identification number of the machine.
- **Operator**: name of the operator conducting the measurement.

- **Run Type**: label identifying the type of run.
- **Param 0,...,3**: custom parameters that the operator can define to differentiate run.
- **Startup Note**: a note that can be added before starting the run.

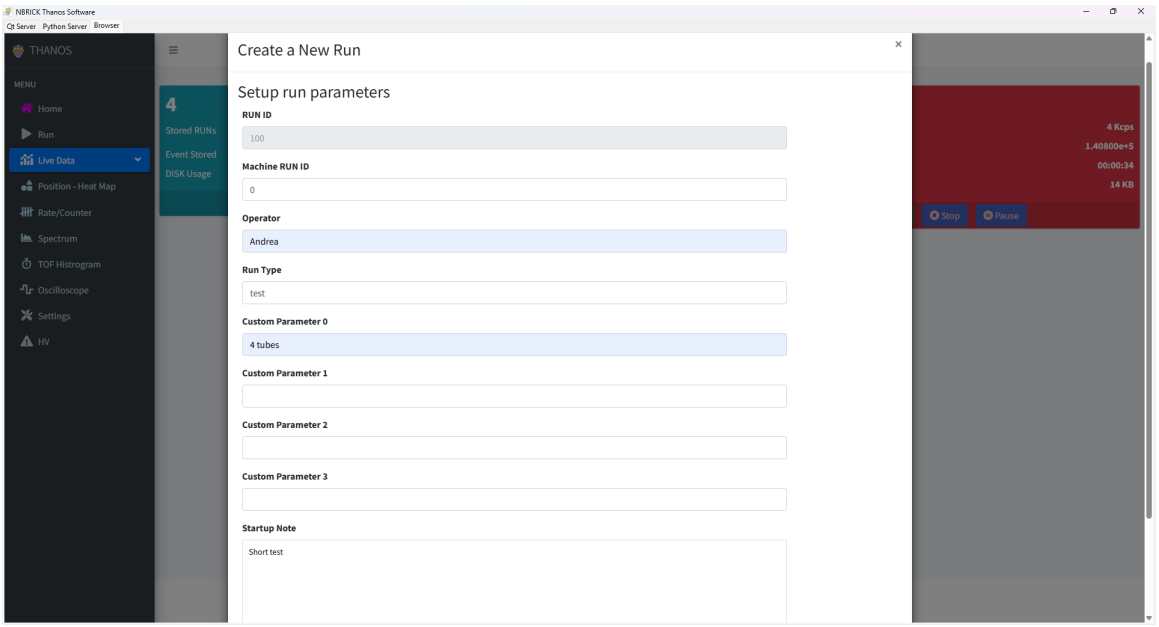


Fig. 4.26: Thanos New Run characterization.

Once the parameters are set, click on "*Start*" to initiate the new run.

After starting, the second panel turns green, indicating that Thanos is RUNNING and the assigned run number is displayed in brackets (Fig. **4.27**).

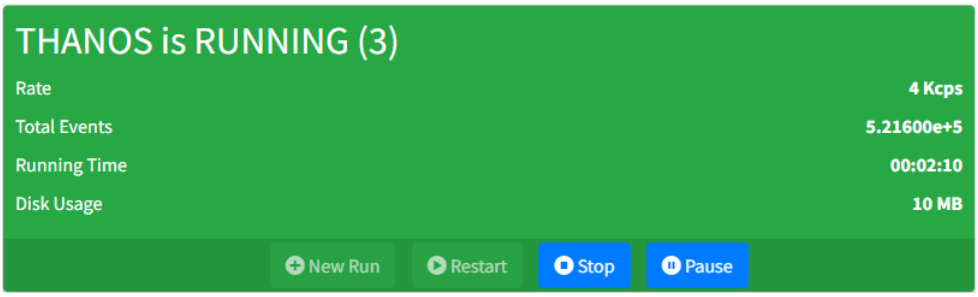


Fig. 4.27: Thanos - Run panel when starting a new run.

During data acquisition, users can pause a run by pressing on "*Pause*" button. When paused, the panel turns yellow and the title updates to indicate that Thanos is Paused. (Fig. **4.28**).

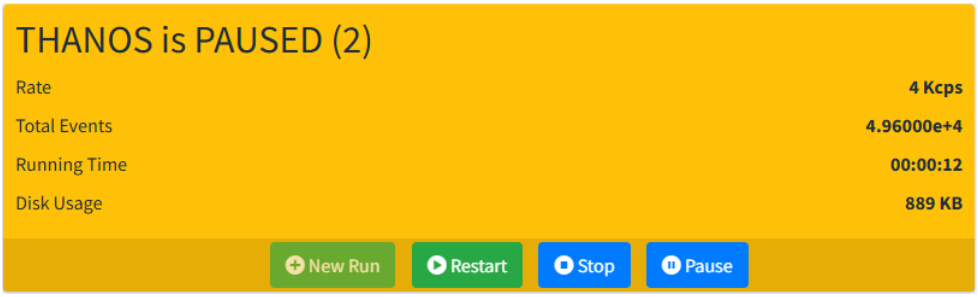


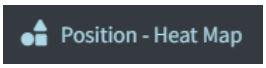
Fig. 4.28: Thanos - Run panel when pausing a run.

Once a run is stopped, it is automatically saved in the database and becomes accessible from the first panel as previously described.

4.2.3 Live Data

The ”Live Data” tab is a drop-down menu which provides options for displaying and saving various real-time plots, including Position - Heat Map plot, Rate/Counter plots, the energy spectrum and the Time-of-Flight (ToF) spectrum. The signal is processed according to a Charge Integration (QDC) firmware (see Sec. **3**) with coincidences, whose parameters can be set in the ”Settings” tab (see Sec. **4.2.5**).

4.2.3.1 Position - Heat Map tab



The ”Position - Heat Map” tab displays the Detector Counts 2D Image, which visualizes event positions along the detector tubes. The X-axis represents the tube number, the Y-axis represents the position of detected events, with a selectable range of 256, 512 or 1024 bit. To modify the Y-axis range, refer to Sec. **4.2.5.2**. The color scale indicates the number of events detected at the same position along the tube.

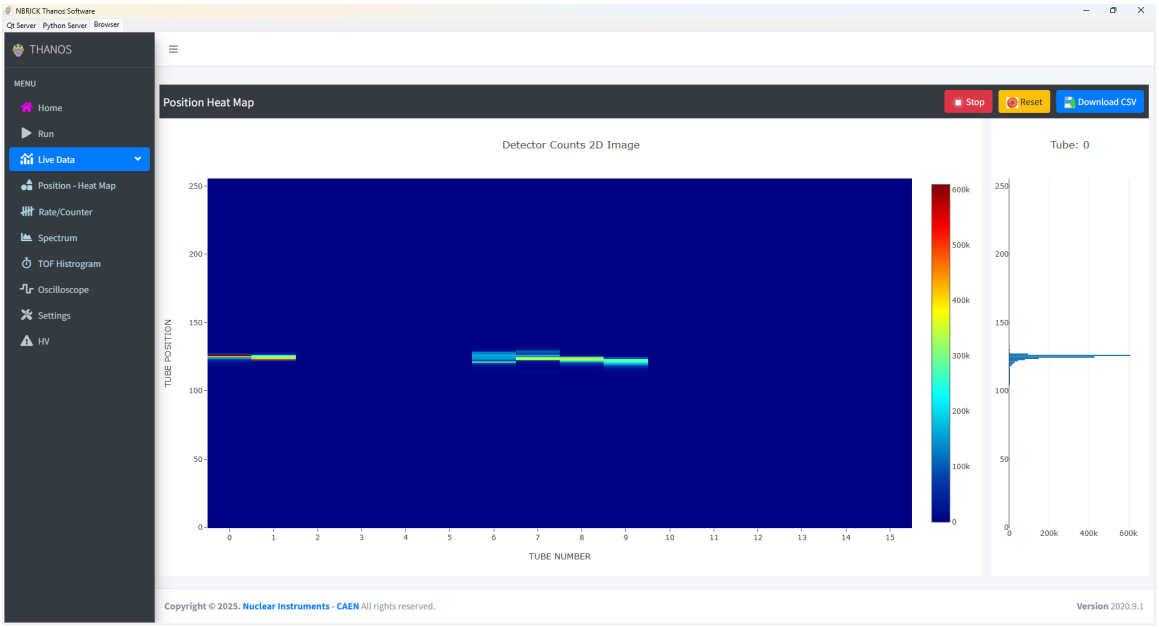


Fig. 4.29: Thanos Position - Heat Map tab. In this example six tubes are connected to the system.

At the top of the interface, a control bar (Fig. **4.30**) displays the plot name and three buttons which allow to Start/Stop the acquisition, Reset data in the plots and Download data in **.csv** format for further analysis. When exporting data, the first row of the file contains the Y-axis label and the list of detector tubes. Subsequent rows contain the counts for each tube, organized accordingly.

Fig. 4.30: Thanos Position - Heat Map control bar.

On the right side of the Position - Heat Map tab, a histogram is displayed, showing the number of counted events at each bit position along the detector tube. Users can select a different tube to display in the histogram by clicking on the corresponding tube within the Heat Map. For example, in Fig. **4.31** Tube 9 is selected, and its event distribution is shown in the histogram.

Both the heat map and histogram plots include a pop-up menu (for example Fig. **4.32**), which appears when hovering the cursor over the upper part of the plot window.

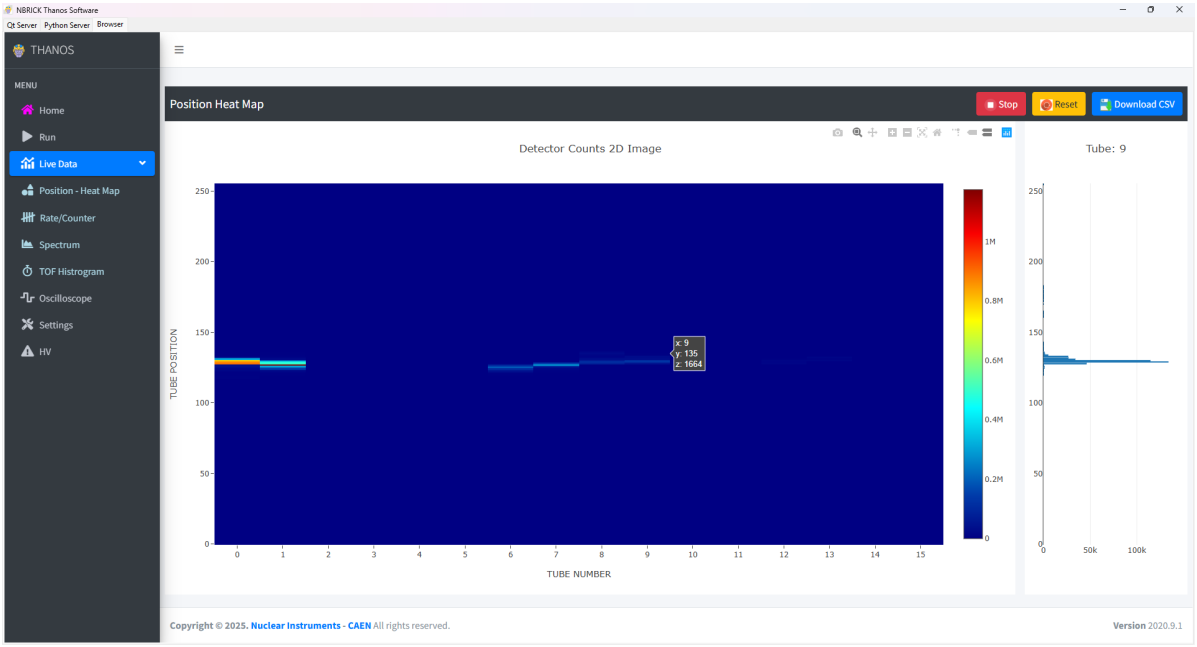


Fig. 4.31: Thanos Position - Histogram of tube 9.

Fig. 4.32: Thanos pop-up menu example.

The plot interaction menu provides access to various buttons and tools for customizing and analyzing plots. The availability and functionality of these tools depend on the specific plot type and whether certain features are enabled or disabled.

Download: saves the plot as a **.png** file.

Zoom: adjusts the view range of the plot, allowing users to perform a rectangular zoom to focus on a specific area. To return to original view, simply double-click on the plot.

Pan: moves the plot view without changing the zoom level.

Box Select: selects a rectangular area within the plot.

Lasso Select: selects an irregular-shaped area within the plot.

Zoom in: enlarges the plot view.

Zoom out: reduces the plot size.

Autoscale: automatically adjusts the scale range of both axes.

Reset Axes: resets the axes scale to default values.

Toggle Spike Lines: displays guidelines for precise data point selection.

Show closest data on hover: highlights the nearest data point when hovering over the plot.

Compare closest data on hover: displays and compares multiple nearest data points from different traces.

Produced with Plotly: indicates that the plot was generated using Plotly.

4.2.3.2 Rate/Counter tab

The ”Rate/Counter” tab provides six selectable plots that display real-time and cumulative counting rates.

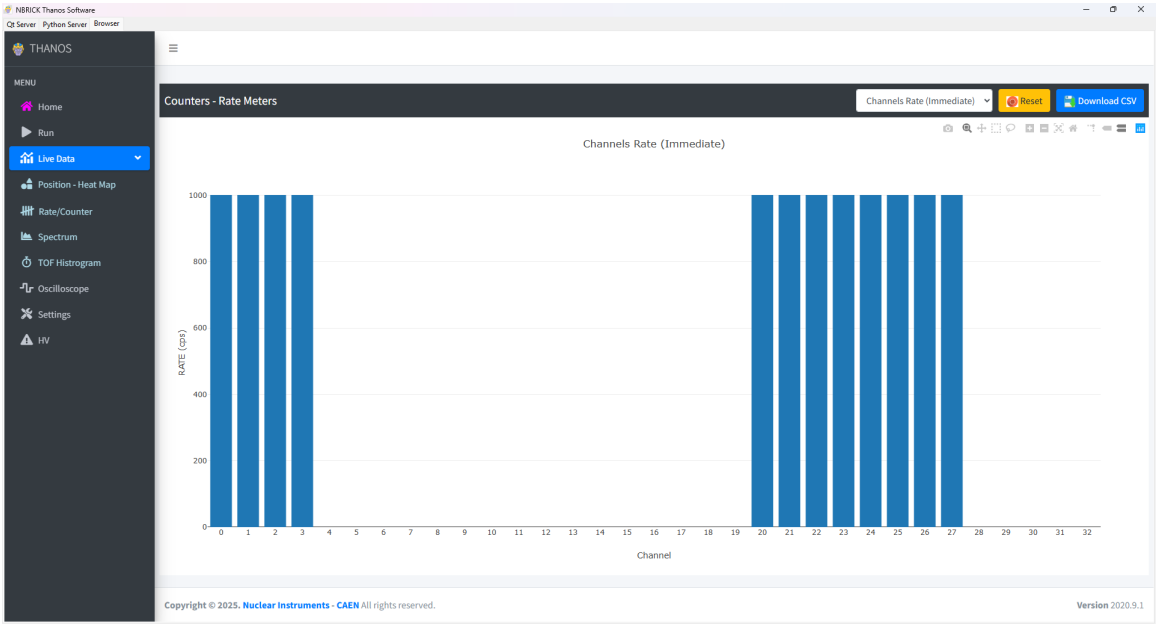


Fig. 4.33: Thanos Rate/Counter tab - Example of Channels rate plot with twelve channels enabled.

At the top of the interface, the control bar (Fig. **4.34**) allows users to select the type of plot to display (listed in the following), to Reset the current plot and to download data of the selected plot as a **.csv** file for further analysis. The data file contains rate or counts (depending on the plot type) for each channel or tube.

Fig. 4.34: Thanos Rate/Counter control bar.

From the drop-down menu (Fig. **4.35**), users can choose from six different plots:

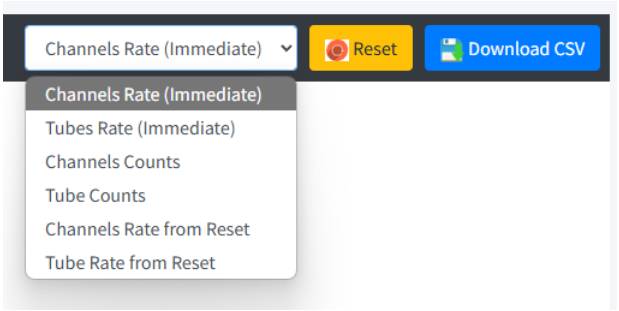


Fig. 4.35: Thanos Rate/Counter drop down menu.

- **Channels Rate (Immediate)**: displays the counts per second detected for each channel.
- **Tubes Rate (Immediate)**: displays the counts per second detected for each tube.
- **Channels Counts**: shows the total event count detected for each channel.
- **Tube Counts**: shows the total event count detected for each tube.

- **Channels Rate from Reset**: displays the counts per second detected for each channel since the last reset.
- **Tube Rate from Reset**: displays the counts per second detected for each tube since the last reset.

For all plots, an interactive toolset can be accessed by hovering the cursor over the upper part of the window. These tools, described in Sec. **4.2.3.1**, allow users to interact with the plots for detailed analysis. In Fig. **4.36** and Fig. **4.37** some examples of the plots explained above are shown.

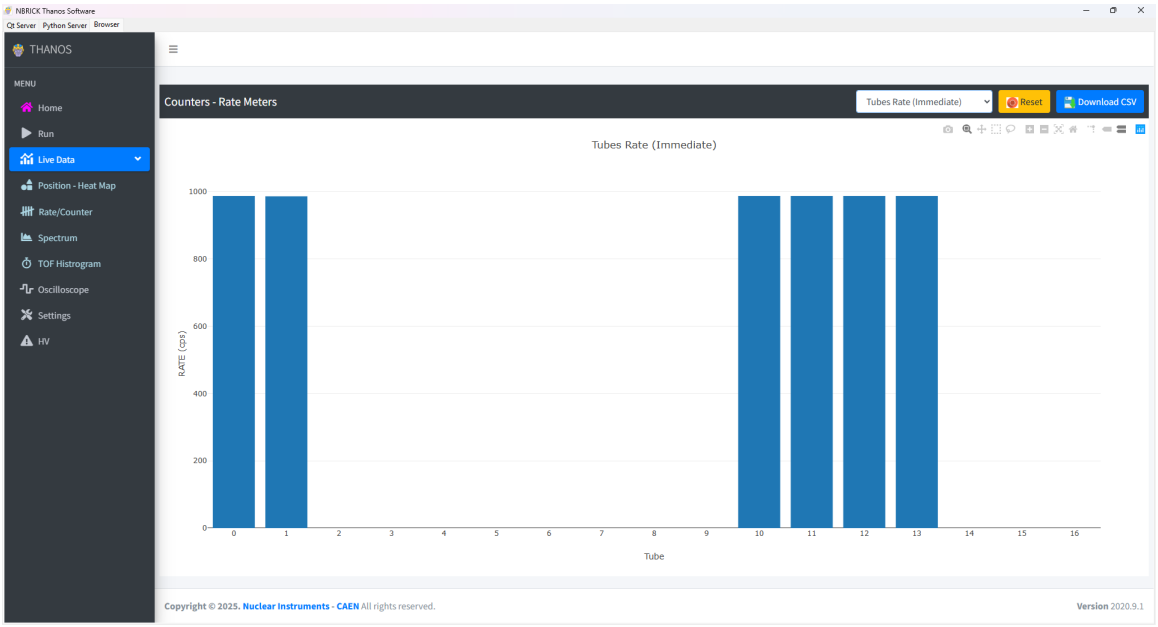


Fig. 4.36: Thanos - Example of Tubes rate plot with six tubes connected.

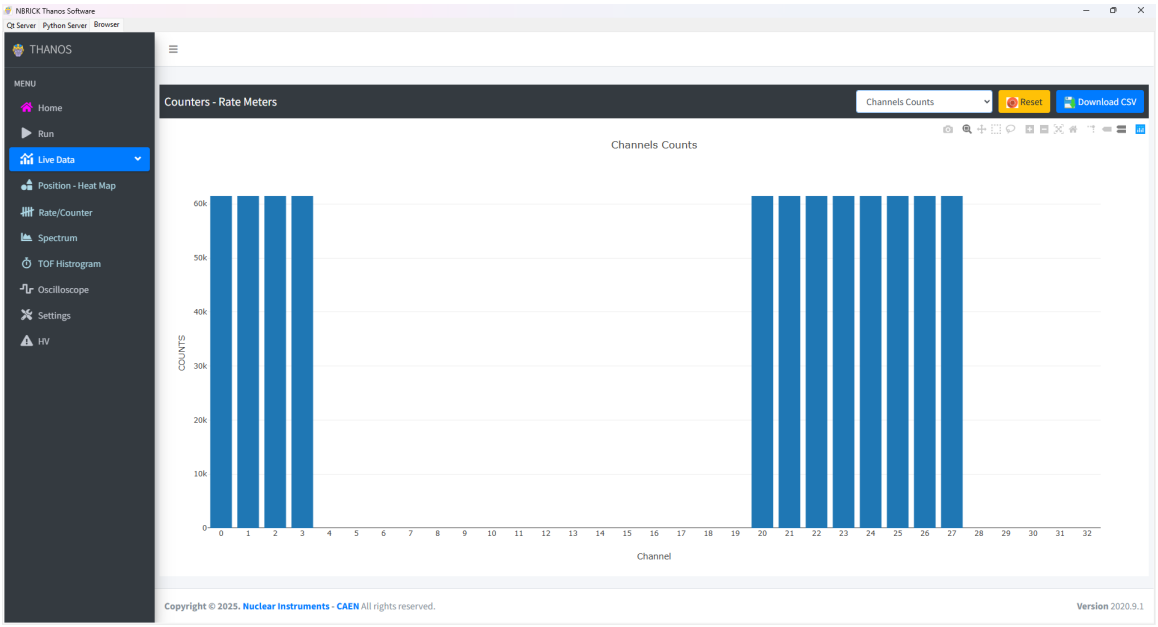
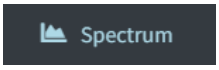


Fig. 4.37: Thanos - Example of Channels counts plot with twelve channels enabled.

4.2.3.3 Spectrum tab



The ”Spectrum” tab displays the Energy Spectrum for each selectable channel. Users can configure the display settings, apply fitting tools, and interact with the spectrum using zoom and visibility controls.

Fig. 4.38: Thanos Energy Spectrum tab. Example acquiring four channels.

The upper control bar provides several options (Fig. **4.39**):

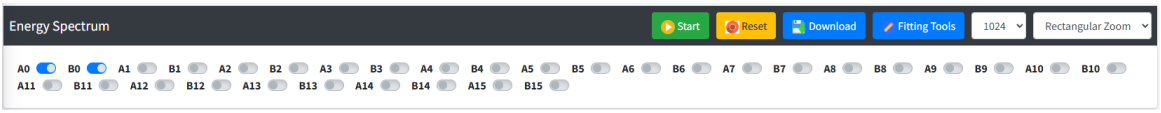


Fig. 4.39: Thanos Energy Spectrum control bar.

- **Start**: Starts/Stops the acquisition of the energy spectrum.
- **Reset**: clears the current spectrum data.
- **Download**: saves the spectrum data as **.txt** file, where the first column reports the values of X-axis, and the other columns (as many as the number of channels enabled) represents the number of counts for each X-axis value.
- **Fitting Tools**: opens an additional dashboard for spectrum fitting analysis (described in the following).
- **X-axis range selection**: adjust the range of the X-axis.
- **Zoom options**: allows users to choose the zoom mode among rectangular, horizontal and vertical zoom.

Below the control bar (Fig. **4.39**) switches allow users to choose from which channels saving data and contemporarly to enable or disable channel traces on the plot.

If a channel is enabled, its trace can be toggled visible/invisible by clicking on its legend symbol. If the text in the legend appears grey, the corresponding trace is not displayed in the spectrum. For example, in Fig. **4.40**, four channels are enabled, but only two traces are currently visible in the spectrum.

Fig. 4.40: Thanos Energy Spectrum legend to show/unshow the traces in the spectrum.

Clicking on  button in the upper-right corner of the plot opens a drop-down menu (Fig. **4.41**) to abilitate the View in full screen, to Print the chart (sends the plot to a printer or saves it as a PDF) and to save the plot in various formats: **.png**, **.jpg** (JPEG), **.pdf** or **.svg** (vector image) file.

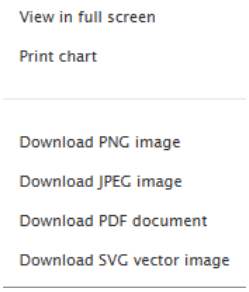


Fig. 4.41: Thanos Oscilloscope drop-down menu.

Fitting Tools Tab

The ”Fitting Tools” tab, located in the upper control bar, opens a dedicated dashboard (Fig. **4.42**). Once the dashboard is opened, the displayed spectrum is frozen, allowing users to perform fitting tasks without the spectrum being updated or modified during the process.

The Fitting Tools bar presents four functionalities:

- **Fit Table**: opens a new control bar to Add new ROI (Region Of Interest), enabling the Automatic Peaks Detection, and Remove ROIs. This section will be described in the following (Fig. **4.43**).
- **Log/Lin**: allows to select Linear or Logarithmic scale for the Y-axis.
- **Calibration Table**: allows users to define a calibration function to convert data between LSB (Least Significant Bit) and keV unit (Fig. **4.49**).
- **LSB/keV**: after performing calibration in the ”Calibration Table” tab, this option allows to choose LSB or keV unit for the X-axis.

Fig. 4.42: Thanos Fitting Tools dashboard.

Fitting Table

The ”Fitting table” is a tool designed to define Regions of Interest (ROI) for spectral fitting, automatically detect peaks, and perform fitting operations on the spectra. Through this feature, users can analyze peak positions, amplitudes, and other relevant characteristics for energy calibration and spectrum analysis.

Fig. 4.43: Thanos Fit Table dashboard.

To create a ROI, press on ”*Add ROI*”, which will generate two vertical lines on the spectrum (Fig. **4.44**). These lines represent the boundaries of the ROI.

Fig. 4.44: Thanos Fit - Add new ROI.

Users can adjust the ROI boundaries by dragging the vertical lines to expand or reduce the selected region and dragging any point within the lines to move the entire region. Then press on "*Confirm*" to apply the changes and perform the fit. (Fig. **4.45**).

Fig. 4.45: Thanos Fit - ROI confirmation.

Click on "*Automatic Peaks Detection*" to scan the spectrum and automatically identify the peaks. The detected peaks are highlighted with green lines in the spectrum, and each identified peak is listed in the Fitting Table, appearing as a new row (Fig. **4.46**).

The Fitting Table consists of fifteen columns providing detailed information about detected peaks:

– **Id**: the identification number of the peak.

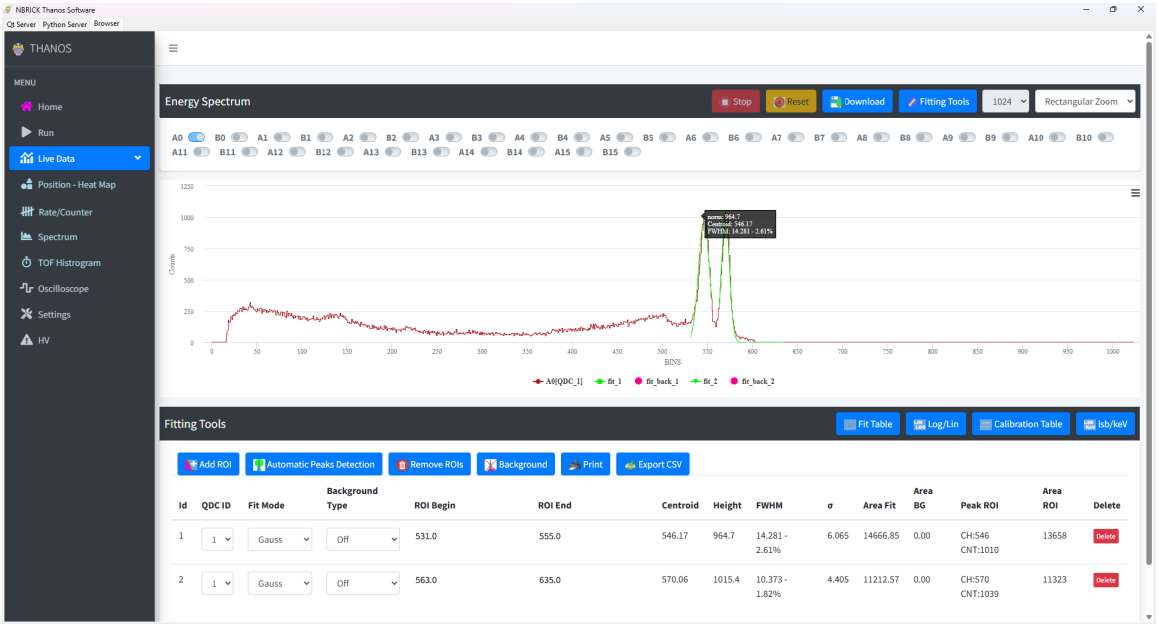


Fig. 4.46: Thanos Fit - Automatic Peaks Detection.

- **QDC ID**: the identification number of the channel.
- **Fit Mode**: a drop-down menu to select the fitting mode between Gaussian or Compton options.
- **Background Type**: allows to choose the Background model, with available options: Off, Constant, Linear, Quadratic, Cubic, 4^{th} Order and 5^{th} Order.
- **ROI Begin/ ROI End**: the start and end positions of the ROI (in LSB).
- **Centroid**: the estimated centroid of the peak (in LSB).
- **Height**: the estimated peak amplitude (in counts).
- **FWHM**: the Full Width at Half Maximum (FWHM) of the peak (in LSB).
- σ: The standard deviation of the peak (in LSB).
- **Area Fit**: the integrated area under the fitted peak.
- **Area BG**: the background area under the peak.
- **Peak ROI**: the coordinates of the detected peak within the ROI.
- **Area ROI**: the total ROI area.
- **Delete**: a button allowing users to remove the ROI from the table.

Once peaks are detected and listed in the table, the control bar provides additional tools (Fig. **4.47**):

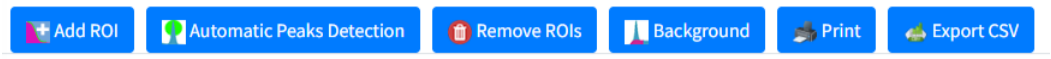


Fig. 4.47: Thanos Fit - Control bar.

- **Remove ROIs**: removes all ROIs from the Fitting Table.
- **Background**: shows or hides the estimated background components in the fit.
- **Print**: generate a printable report of the fitting results.
- **Export CSV**: saves the fitting results in a "**.csv**" file for external analysis.

The Fit results are stored in a file named ”ThanosServer_fit_results.csv”, which includes the following parameters:

- **ID/CHANNEL**: peak ID and corresponding channel.
- **ROI_START_LSB (KEV)/ROI_END_LSB (KEV)**: ROI start and end positions in LSB and keV.
- **CENTROID_LSB (KEV)**: estimated centroid in LSB and keV.
- **NORM**: estimated normalization in LSB.
- **SIGMA_LSB (KEV)/VARIANCE_LSB (KEV)/FWHM_LSB (KEV)**: estimated σ, variance and Full Width at Half Maximum in LSB and keV.
- **FIT_AREA/BKG_AREA/ROI_AREA**: estimated areas under the fit and of the background, and the total area of the ROI.
- **FIT_MODEL/BACKGROUND_MODEL**: fitting model and background model used for peak analysis.

Note: Parameters expressed in keV are only available after performing a calibration. If no calibration has been applied, these fields will display ”NaN” (Not a Number).

Fig. **4.48** illustrates an example of different background components that can be applied to the ROI. Adding background components influences the calculated peak parameter described above.

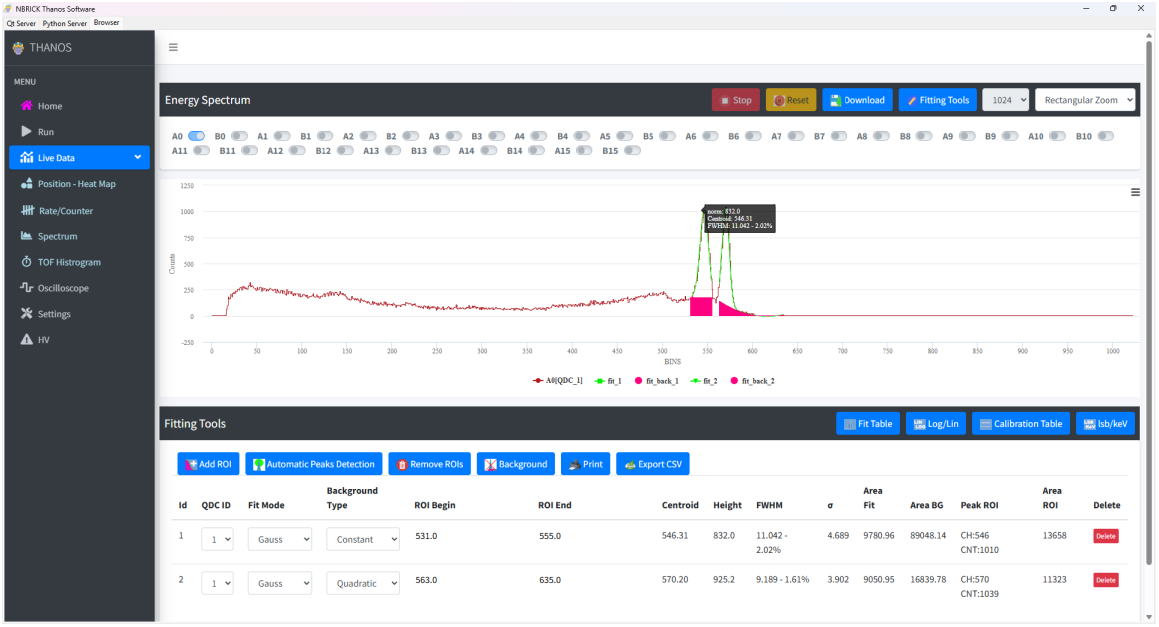


Fig. 4.48: Thanos Fit - Background examples.

Note: Users can also toggle the visibility of individual traces in the plot (including the fit and background traces) by clicking on their corresponding legend symbols.

Calibration Table

The ”Calibration Table” allows users to define a calibration to convert values between LSB units to keV units (Fig. **4.49** shows an example with two spectra).

The dashboard includes a control bar to Add a new calibration, Import existing ROIs from the Fitting Table, Set or Reset the calibration. The last drop-down menu allows users to select the energy fit model, choosing from Linear, Quadratic, Cubic, 4^{th} order and 5^{th} order.

To manually define a new calibration point, users can click ”*Add*”, which inserts a new row into the calibration table. Here, users must enter the centroid value (corresponding BIN position) and its associated

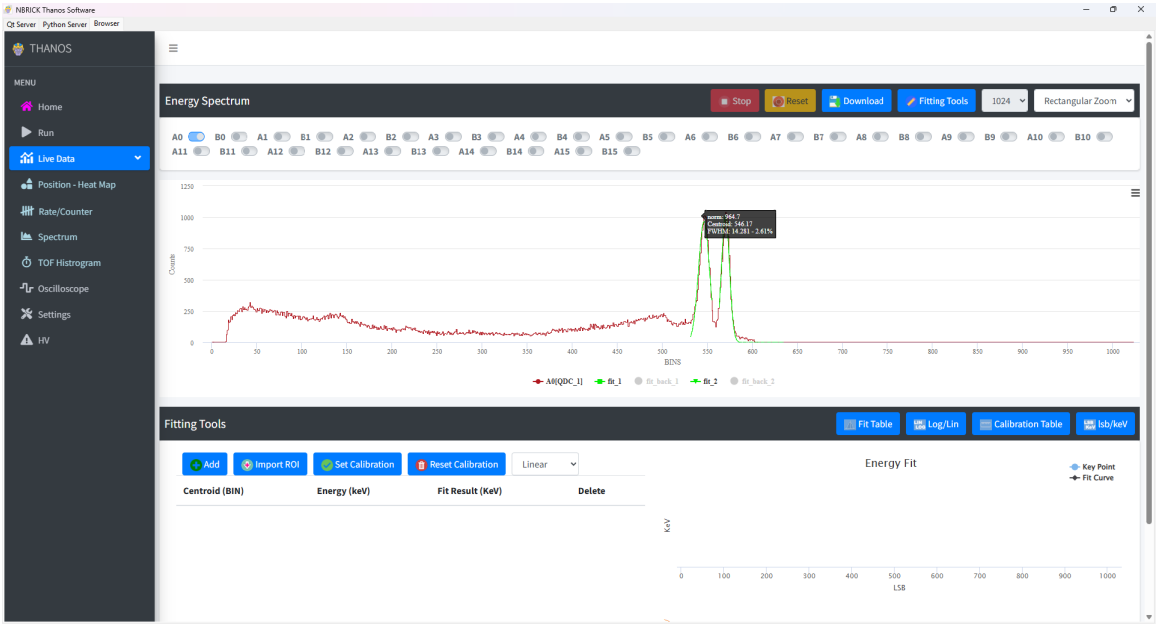


Fig. 4.49: Thanos Calibration Table dashboard.

energy value in keV.
Alternatively, presssing "*Import ROI*" automatically retrieves the ROI data from the Fitting Table.

Fig. **4.50** shows an example of a calibration table with multiple peaks.

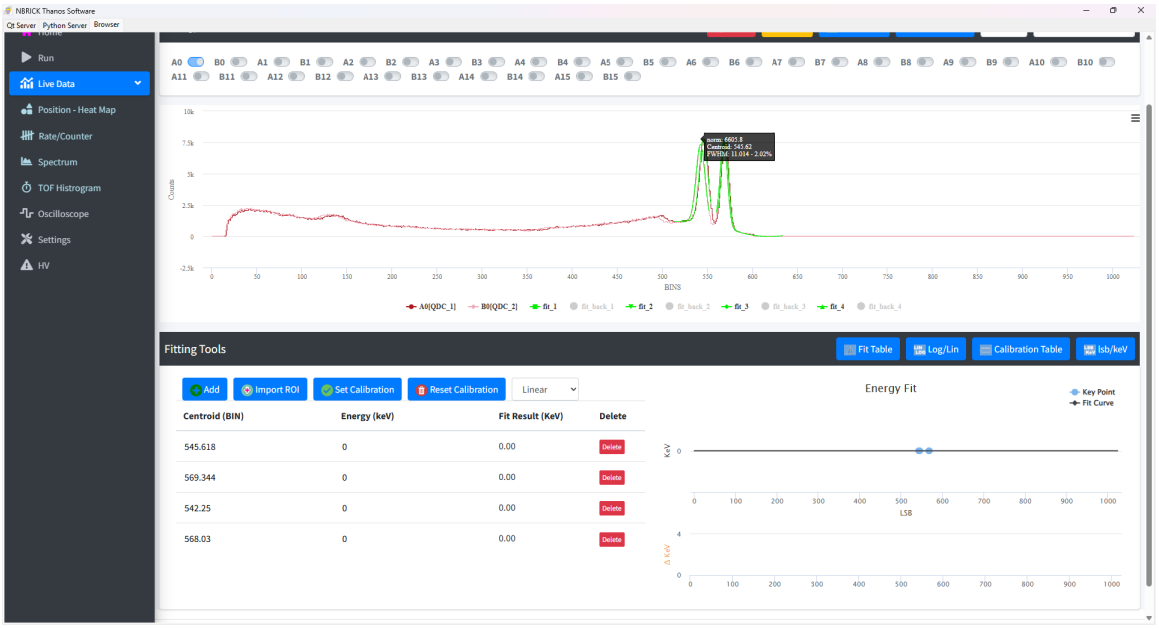


Fig. 4.50: Thanos Calibration Table example with two spetrum.

Users can enter manual energy values for calibration, and the software will automatically compute the corresponding fit results. Individual rows can be removed if necessary by clicking on Delete button.
The calibration results are shown in Fig. **4.51**, featuring two spectra fitted using a Linear energy fit.

On the right side of the dashboard, two calibration-related plots are displayed:

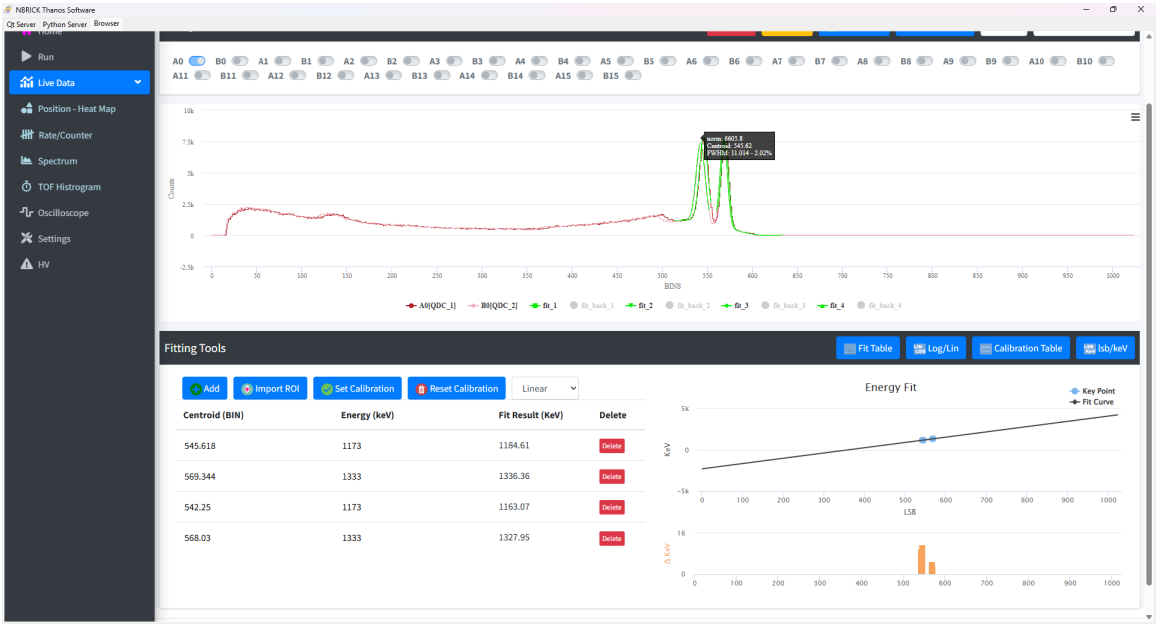


Fig. 4.51: Thanos Calibration Table results featuring two spectra fitted using Linear Energy fit.

- **Energy Fit Plot**: displays the calibrated data points and the corresponding fitted curve.
- Δ **keV Plot**: shows the residual between the points and the fitted curve.

By hovering with the cursor over the Energy Fit Plot, users can view a box displaying the fit values along the curve (Fig. **4.52**).

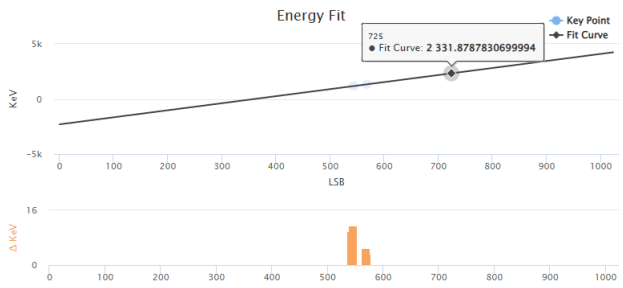
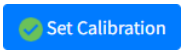


Fig. 4.52: Thanos Energy Fit results.

Once the calibration is complete, users can apply it by clicking on 

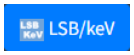
button in the Fitting Tools control bar. Then users can updates the X-axis scale from LSB to keV and vice versa, pressing on 

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Fig. **4.53** shows an example where a spectrum originally plotted in LSB is successfully converted to keV energy units.

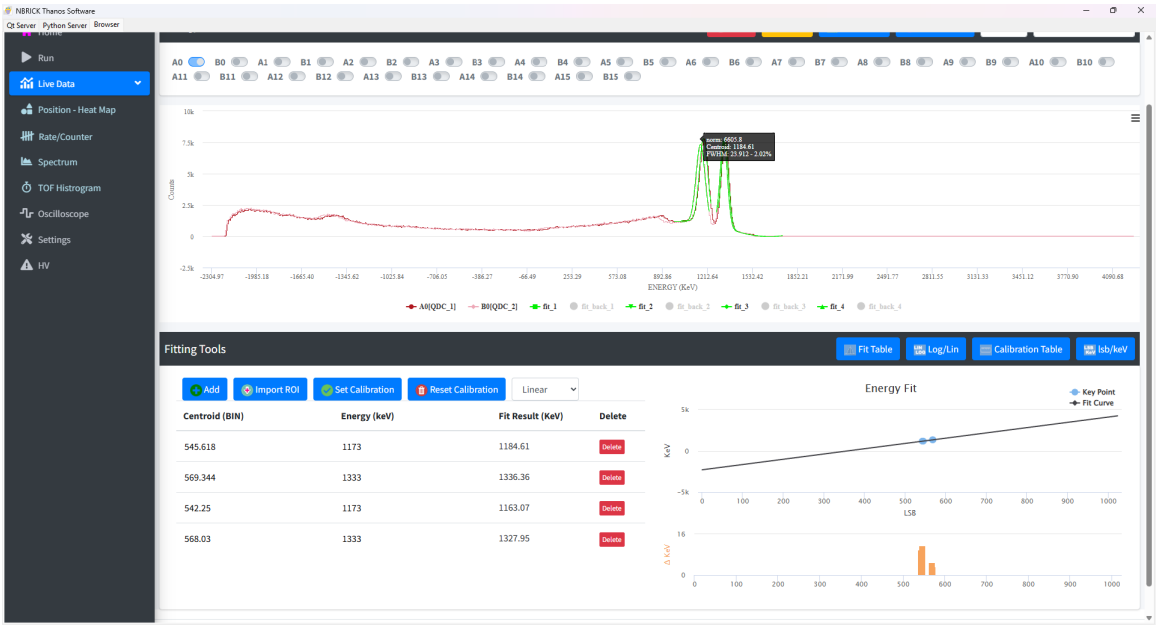
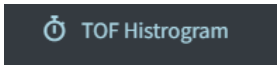


Fig. 4.53: Thanos Conversion from LSB to keV energy units.

4.2.3.4 ToF Histogram tab



The ”ToF” tab displays the Time-of-Flight plot, calculated assuming that an external reference signal is fed into the R5560C, through the LEMO IN ports.

To configure the system to correctly interpret the T_0 reference signal via the LEMO_IN_0 port, users must adjust DAQ SYNC settings. This is done by changing the first row of the DAQ SYNC options to ”LEMO IN 1” using the touchscreen display interface, as shown in Fig. **4.54**.

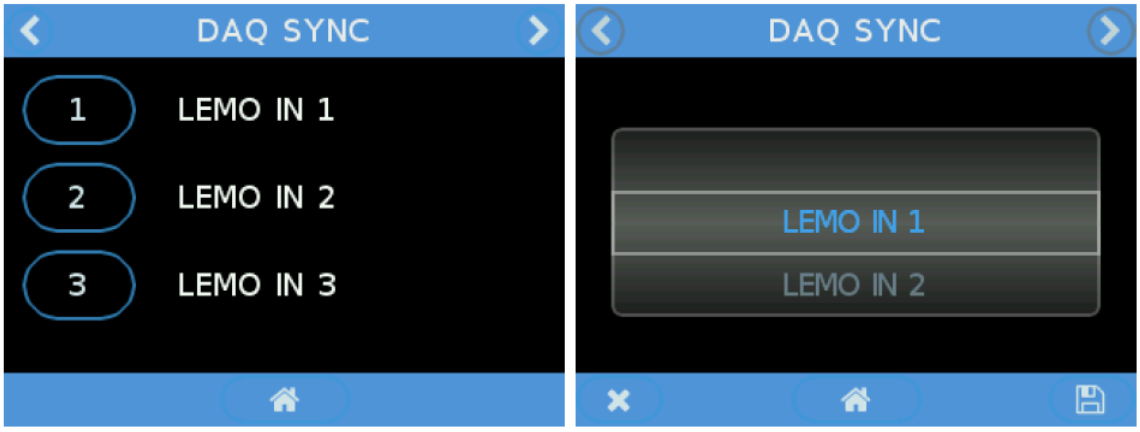


Fig. 4.54: Configure DAQ SYNC to LEMO IN 1.

The ToF measurement represents the time difference between the reference signal (T_0 LEMO input) and the arrival time of the neutron signal on a given channel.

Fig. **4.55** displays an example of Thanos ToF Histogram Tab, which provides a visual representation of the ToF distribution.

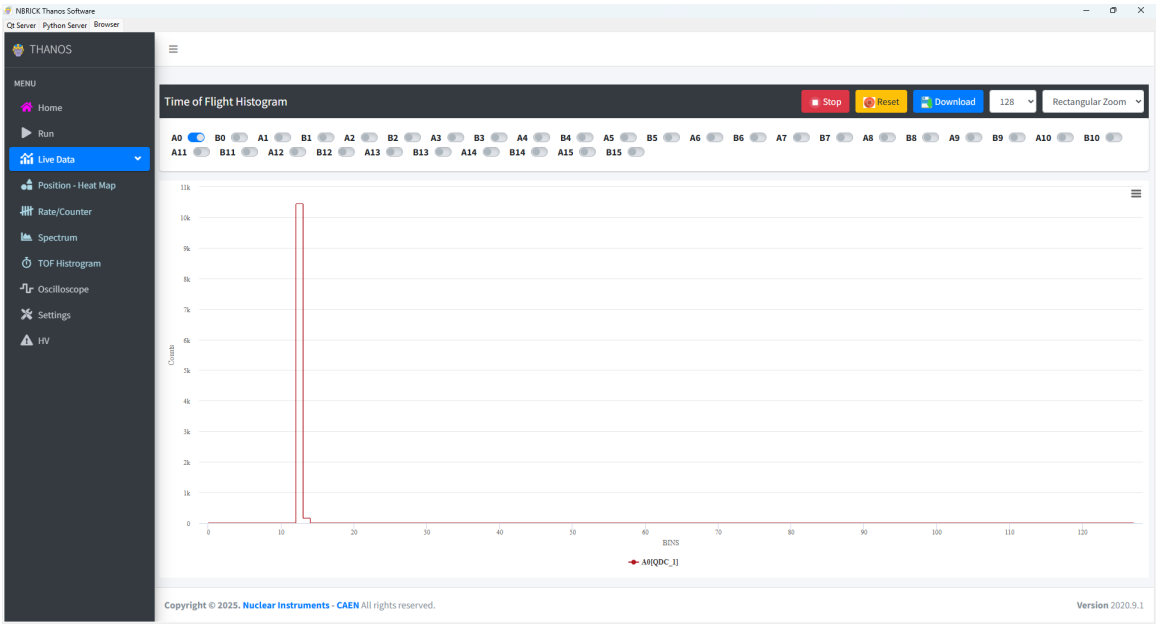


Fig. 4.55: Thanos ToF Histogram tab - Example of ToF Histogram.

In this example, the parameters in the ”ToF” panel (accessible from the ”Settings” tab, see Sec. **4.2.5.2** for

more details) were configured to use a binning of 16 ns/bin and a maximum bin number of 4K (4096). This means that the full scale of the ToF histogram spans 4096 bins, wit each bin representing 16 ns. However, for visualization purposes, the plot scale was adjusted to display only 128 bins, effectively compressing the full scale by a factor of 32 (i.e. 4096/128 = 32). As a result, the time length of each displayed bin becomes 32 x 16 ns/bin = 512 ns/bin. In this scenario, the T_0 reference signal and the signal from the per-amplifier input were delayed by 6 µs, which corresponds to bin 12 in the adjusted scale, as shown in Fig. **4.56**. This example illustrates how changes in display binning directly affect the time resolution of the histogram.

Note: The electronic processing of the signals entering the pre-amplifier, along with the length of the connecting cables, introduces an intrinsic delay between these signals and the T0 reference signal, which is sent directly to the LEMO IN 0 input of the Digitizer. This delay should be taken into account when analyzing Time-of-Flight measurements.
In a controlled test using a Digital Detector Emulator DT5800, both the T0 reference signal and the signals sent to the pre-amplifier were generated simultaneously. The setup included 1-meter cables for both the LEMO IN 0 and pre-amplifier inputs, and 2-meter Ethernet cables to communicate among themselves. Under these conditions, the delay introduced (mainly from the pre-amplifier stage) was estimated to be approximately **600 ns**.

The upper control bar provides several options (for managing the ToF spectrum acquisition and visualization:

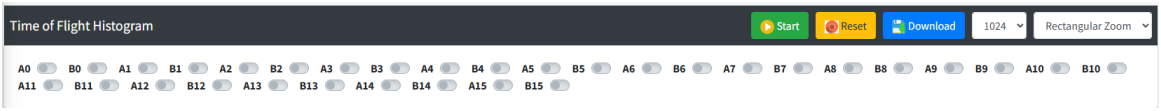


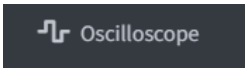
Fig. 4.56: Thanos ToF Spectrum control bar.

- **Start**: Starts/Stops the acquisition of the ToF spectrum.
- **Reset**: clears the current ToF plot data.
- **Download**: saves the ToF data as **.txt** file, where the first column contains the X-axis values (i.e. the time difference between signals), while the remaining columns contain the bin counts for each enabled channel.
- **X-axis binning selection**: adjust the binning of the X-axis.
- **Zoom options**: allows users to choose the zoom mode among rectangular, horizontal and vertical zoom.

Similar to the ”Spectrum” tab, the ToF tab includes switches below the control bar (Fig. **4.56**) that allow users to select channels for data saving and contemporarly enable or disable channel traces on the plot.
Clicking on button in the upper-right corner of the plot opens a drop-down menu (Fig. **4.41**) to abilitate the View in full screen, to Print the chart (sends the plot to a printer or saves it as a PDF) and to save the plot in various formats: **.png**, **.jpg** (JPEG), **.pdf** or **.svg** (vector image) file.

Additionally, when a channel is enabled, its trace can be toggled visible/invisible by clicking on its legend symbol. If the legend text appears grey, the corresponding trace is not displayed in the ToF plot.

4.2.4 Oscilloscope tab



The ”Oscilloscope” tab allows to monitor the input signals and set the triggering mode and the absolute threshold.

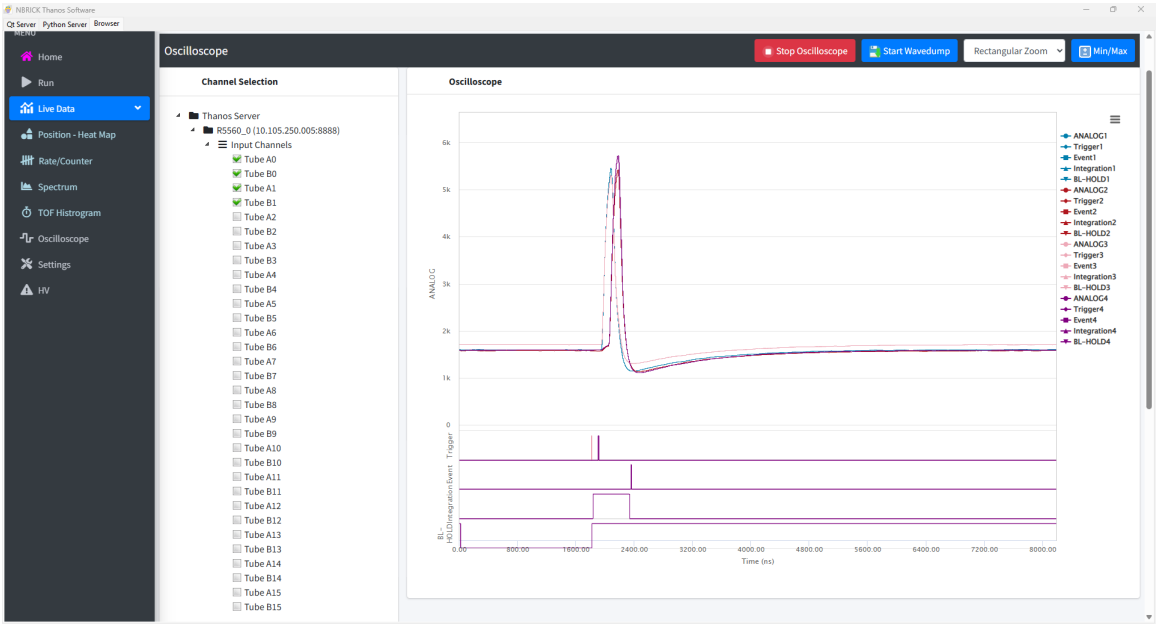


Fig. 4.57: Thanos Oscilloscope tab. Example with the first four channels enabled.

Fig **4.57** shows an example of oscilloscope acquisition with four pre-amplifier channels, corresponding to two connected detector tubes.

The upper control bar provides several options (Fig. **4.58**):

Fig. 4.58: Thanos Oscilloscope control bar.

- **Start Oscilloscope**: Starts or stops the oscilloscope acquisition.
- **Start Wavedump**: starts counting and saving waveforms acquired from the enabled channels (Fig. **4.59** shows an example where the waveforms are being counted). When the acquisition is stopped, a file named ”oscilloscope_0_0.**n**WaveDump.csv” is automatically saved, where ”**n**” represents the total number of counted waves for each enabled channel. The data file is structured as following:
  - every 5 rows represents a wave acquisition. Waves are acquired every 25 milliseconds from each enabled channel and are stored sequentially according to the channel acquisition order.
  - the first of this five rows contains wave values, expressed in 1024 samples.
  - the next four rows represent digital signal (described later), also in 1024 samples.

  Waves are saved with a rate of 4 Hz (4 waves every second for each enabled channel).
- **Zoom options**: allows users to choose the zoom mode among rectangular, horizontal and vertical zoom.

- **Min/Max**: allows to set the Y-scale mode. Default option is ”Autoscale”, the Y-axis range adjusts dynamically based on the waveform peaks. ”Min/Max” mode fixes the Y-axis range, initially setting the maximum value to 5000. If a pulse exceeds this range during acquisition, the system will automatically reset the scale, updating the maximum value to be 10% higher than the signal peak, ensuring the full waveform remains visible.

From the ”Channel Selection” panel, it is possible to select which signals to acquire using the check buttons in the left-hand list of all channels.

Note: A maximum of four channels can be displayed simoultaneously in the Oscilloscope plot. To display additional channels, users must deselect one or more active channels before selecting new ones.

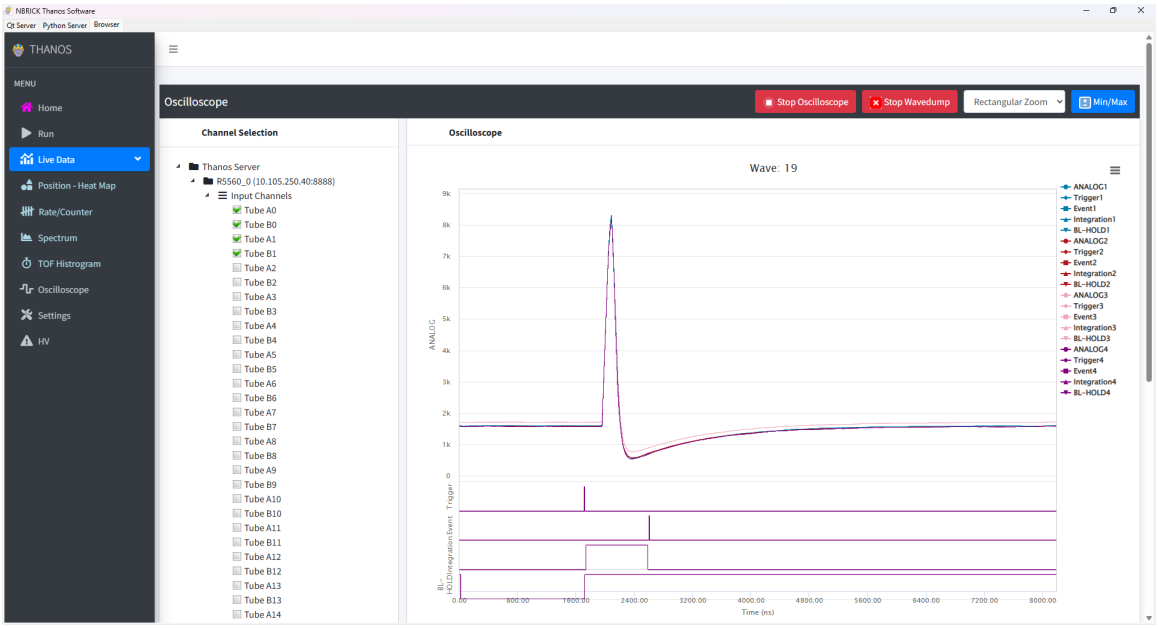


Fig. 4.59: Thanos Oscilloscope Wavedump example.

In the lower plot, the following digital signals are displayed:

- **Trigger signal**: indicates the moment when an event is detected.
- **End of Event**: marks the termination of the detected event. This represents the end of the integration gate, meaning the signal is integrated up to this point, after which the integrated charge value is recorded and added to the energy spectrum.
- **Integration Gate**: represents the time window used for charge integration.
- **Baseline Hold-off**: shows the period during which the baseline level is stabilized before the next event is processed.

Users can show or hide traces in the plot by clicking on the corresponding signal name in the legend. Clicking on button in the upper-right corner of the plot opens a drop-down menu (Fig. **4.41**) to abilitate the View in full screen, to Print the chart (sends the plot to a printer or saves it as a PDF) and to save the plot in various formats: **.png**, **.jpg** (JPEG), **.pdf** or **.svg** (vector image) file.

Scrolling through the Oscilloscope window, users can access the ”Oscilloscope Settings” panel, which allows configuration of key acquisition parameters:

- **Decimator**: controls the sampling rate by reducing the number of acquired data points. Specifically, it retains one sample every N points, where N is the value set in this field, effectively downsampling the signal.

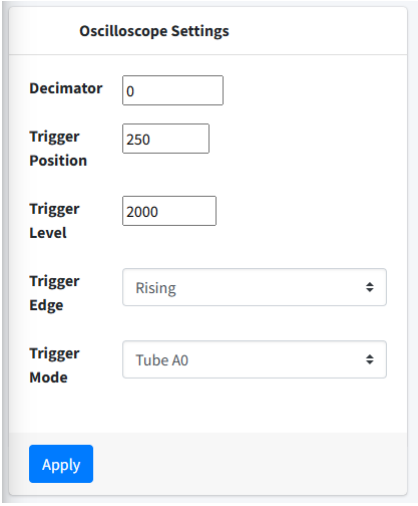


Fig. 4.60: Thanos Oscilloscope Settings.

- **Trigger position**: defines the absolute trigger position, applied to all channels.
- **Trigger Level**: sets a common absolute threshold for all channels.
- **Trigger Edge**: configure the trigger edge type between Rising and Falling.
- **Trigger Mode**: defines how the trigger is activated, selectable from the drop-down menu (Fig. **4.61**):
  - **External trigger**: uses an external signal to trigger acquisitions.
  - **Free running**: continuously acquires data without a trigger.
  - **Channel trigger** A_n, B_n: triggers on the signal of a specific channel.

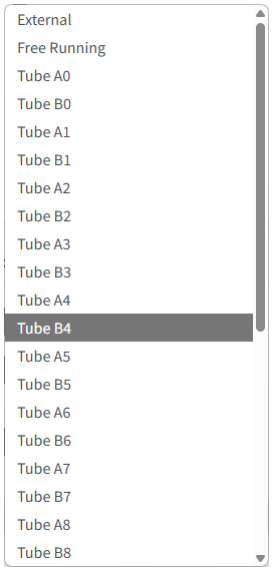
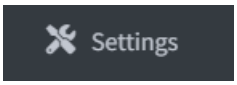


Fig. 4.61: Thanos trigger mode drop-down menu.

Note: To confirm any changes made to the settings, users must click the ”Apply” button located at the bottom of the dashboard. It is recommended to verify that the changes have been successfully applied. If not, users should press the ”Apply” button again to ensure the settings are correctly updated.

4.2.5 Settings tab



The ”Settings” tab allows to configure some important parameters useful for the data acquisition and the firmware’s algorithm functioning.

4.2.5.1 Settings dashboard

The first dashboard allows to configure key acquisition parameters:

- **Polarity**: sets the polarity of the input signal (Positive or Negative). This setting must match the polarity of the input signal from the pre-amplifier channels. The digitizer accepts only positive signals, so when set to Negative, the Thanos software automatically inverts the signal.
- **Offset (LSB)**: defines the DC Offset value to be added to the signals.

Note: The digital offset option only affects the display of the signal in the Oscilloscope tab, but it **does not** apply a physical offset to the signal.

- **Baseline Mode**: defines the number of counts used to calculate the average baseline value.
- **Baseline Hold off (ns)**: defines the time interval during which the baseline value is preserved.
- **Trigger Mode**: configures the trigger condition between each couple of channels An - Bn. Available options are: OR, AND and SUM A+B.
- **Trigger Mask**: a checklist that allows users to select which tubes partecipate in the trigger request.

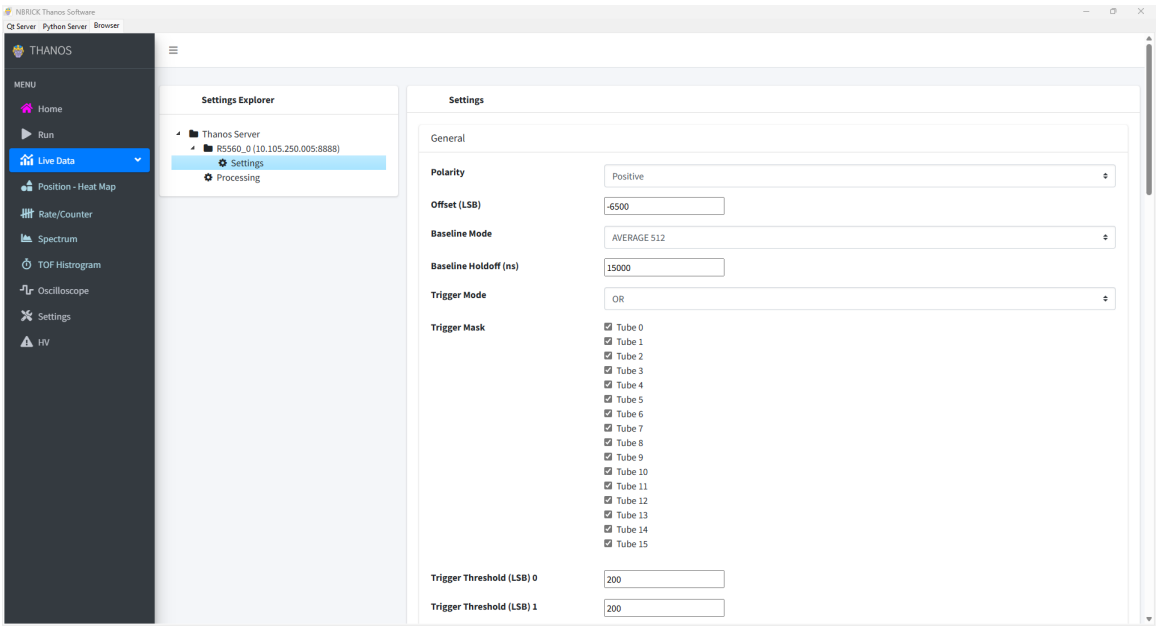


Fig. 4.62: Thanos Settings tab.

- **Trigger Threshold (LSB) [0,...,15]**: sets the trigger threshold for each tube detector.
- **Trigger Hold Off (ns)**: defines the time interval during which the trigger is inhibited and cannot be rearmed.
- **Coincidence Window (ns)**: defines the time window within which multiple signals must occur to be considered coincident.

- **Pre Gate (ns)**: specifies the time interval before the trigger, ensuring that the entire signal, including its initial portion, is properly integrated without loss.
- **Gate Width (ns)**: defines the duration of the integration gate, which determines the time over which the signal is integrated for charge measurement.

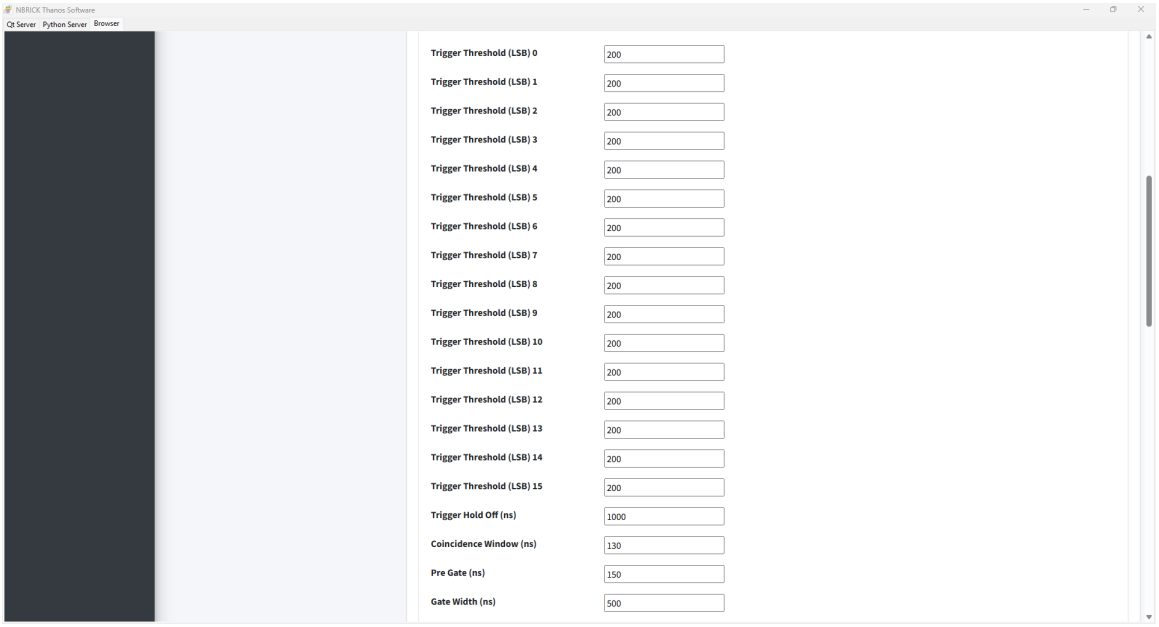


Fig. 4.63: Thanos Settings tab.

- **Fine Gain** A_n**,** B_n: defines the gain factor applied to each channel, that allows users to fine-tune the energy spectrum binning. It can be set individually and the acceptable range is from 0 to 1.
- **Analog Probe**: selects which signal is associated to the Analog trace in the readout data (Oscilloscope). Options are Analog or Baseline. In "Baseline mode" waveforms are acquired and saved in any case during a RUN.
- **Noise Filter**: is a moving average filter that smooth the input signals. Each input sample is replaced by the mean value of all samples within the filter window. The window width is user-configurable and can be disabled or selected from a set of fixed values: 32 ns, 64 ns, 128 ns, 256 ns, 512 ns, 1 µs, 2 µs, 4 µs.

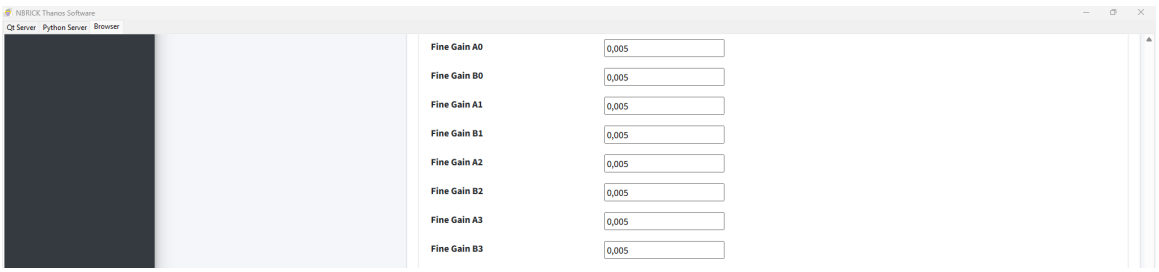


Fig. 4.64: Thanos Settings tab.

Note: To confirm any changes to the settings, users must press the Apply button at the end of the dashboard. It is recommended to verify that the changes have been successfully applied. If not, users should press the "Apply" button again to ensure the settings are correctly updated.

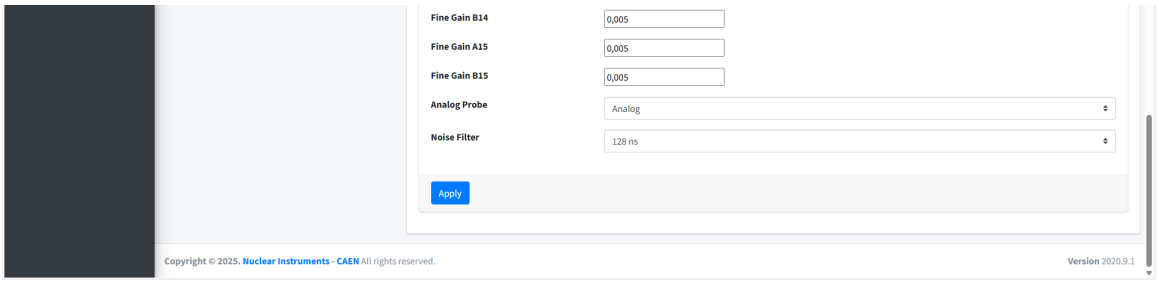


Fig. 4.65: Thanos Settings tab.

FINE GAIN SETTINGS

The **Fine Gain** value can be configured individually for each channel (0,...,32). It is a multiplicative factor applied to the integrated charge value. The acceptable range is 0 to 1. This option is particularly useful for refining the binning of signals in the Spectrum plot, ensuring that spectra align correctly for calibration and comparison (see Sec. **4.2.3.3** for calibration procedure).

Fig. **4.66** illustrates an example where signals from two channels (corresponding to a single detector tube) are displayed. As shown, the spectral peaks appear at different positions.

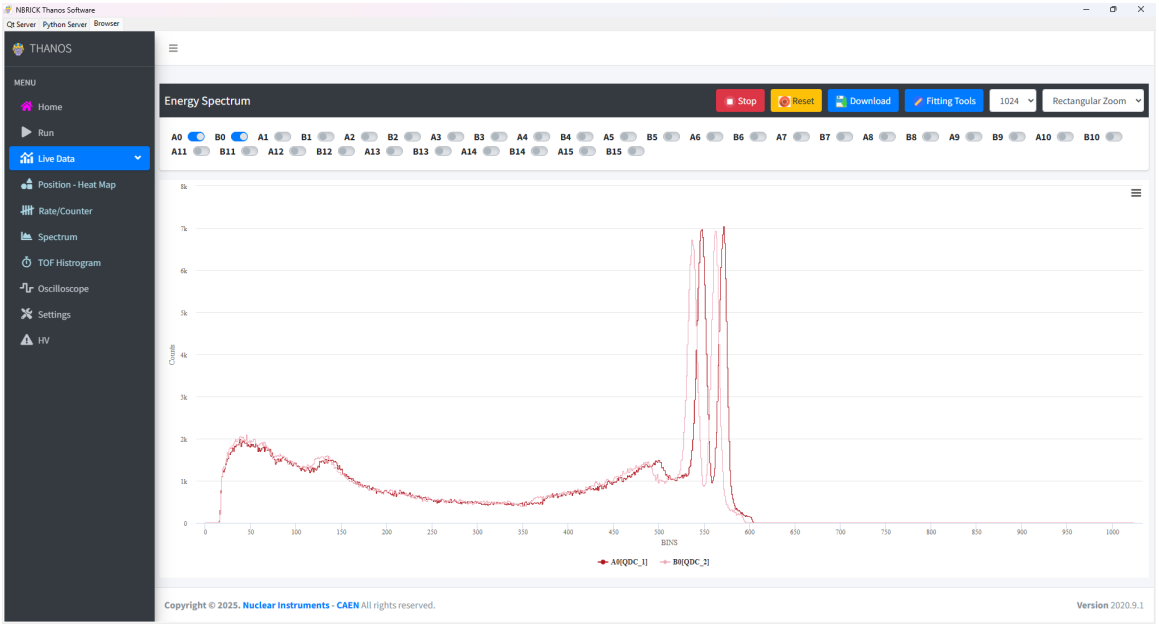


Fig. 4.66: Thanos Fine gain procedure example.

Adjusting the Fine Gain field for channel B0 in the ”Settings” tab, users can observe how increasing the gain value shifts the spectrum to the right. Fig. **4.67** displays this effect, showing a case where two spectra have been approximately aligned by fine-tuning the gain settings.

This procedure can be repeated for additional channels, ensuring that all spectra from different tubes align properly. Fig. **4.68** shows an example where four spectra (from two connected tubes) have been aligned.

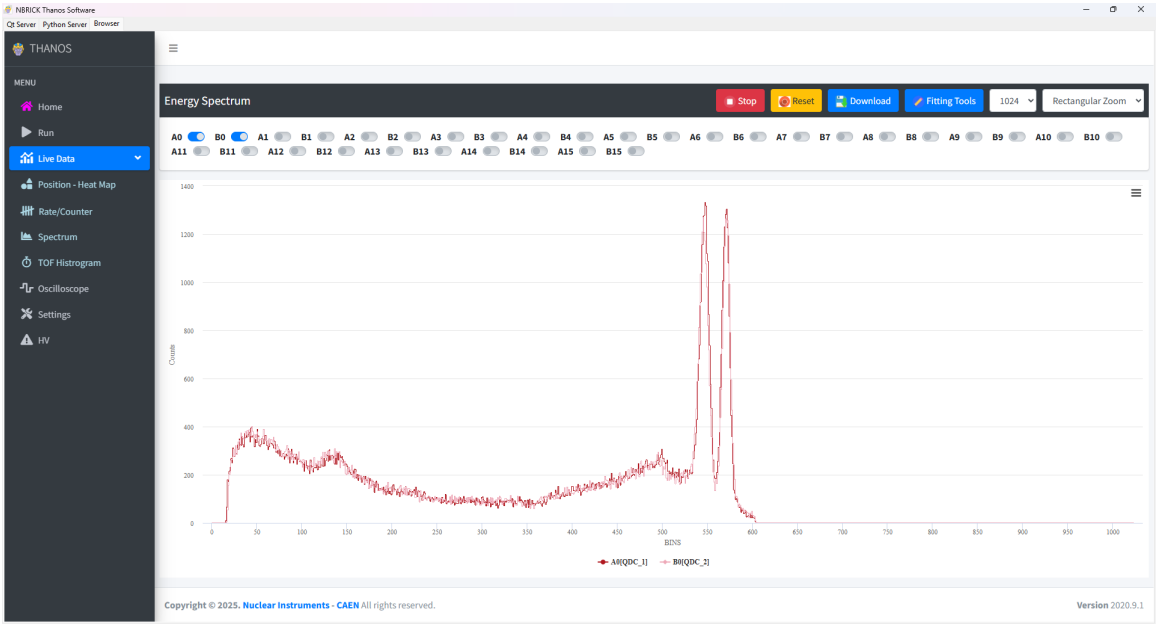


Fig. 4.67: Thanos Fine gain procedure example.

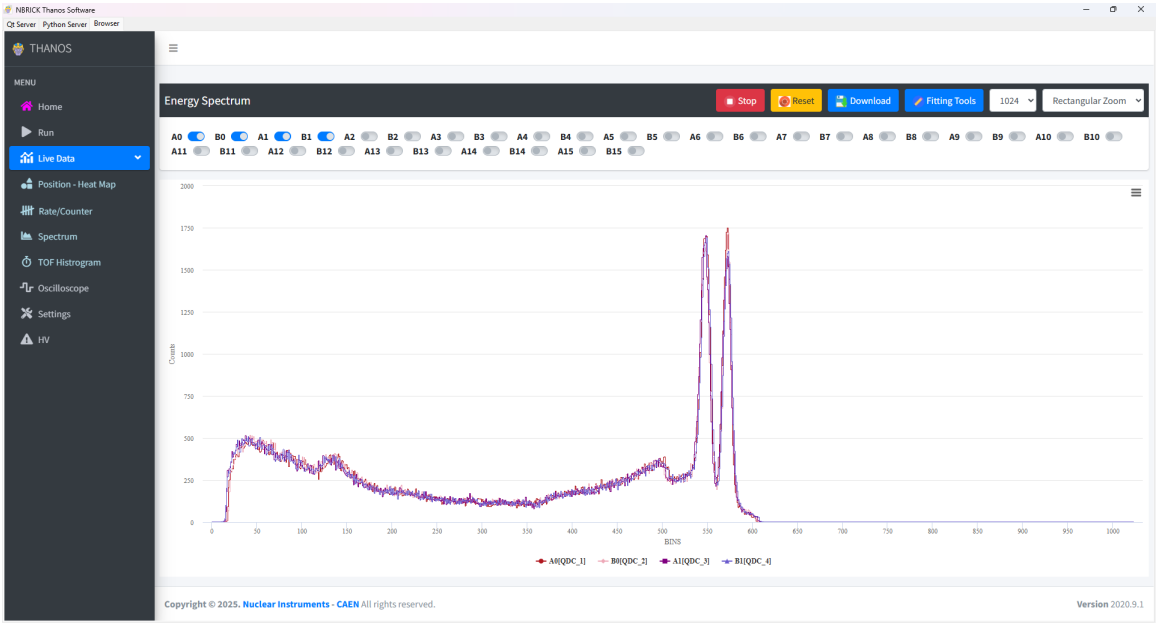


Fig. 4.68: Thanos Fine gain procedure example.

4.2.5.2 Processing dashboard

From the ”Setting Explorer” menu, located on the left side of the ”Oscilloscope” window, users can access additional settings by clicking on ”Processing” (Fig. **4.70**).

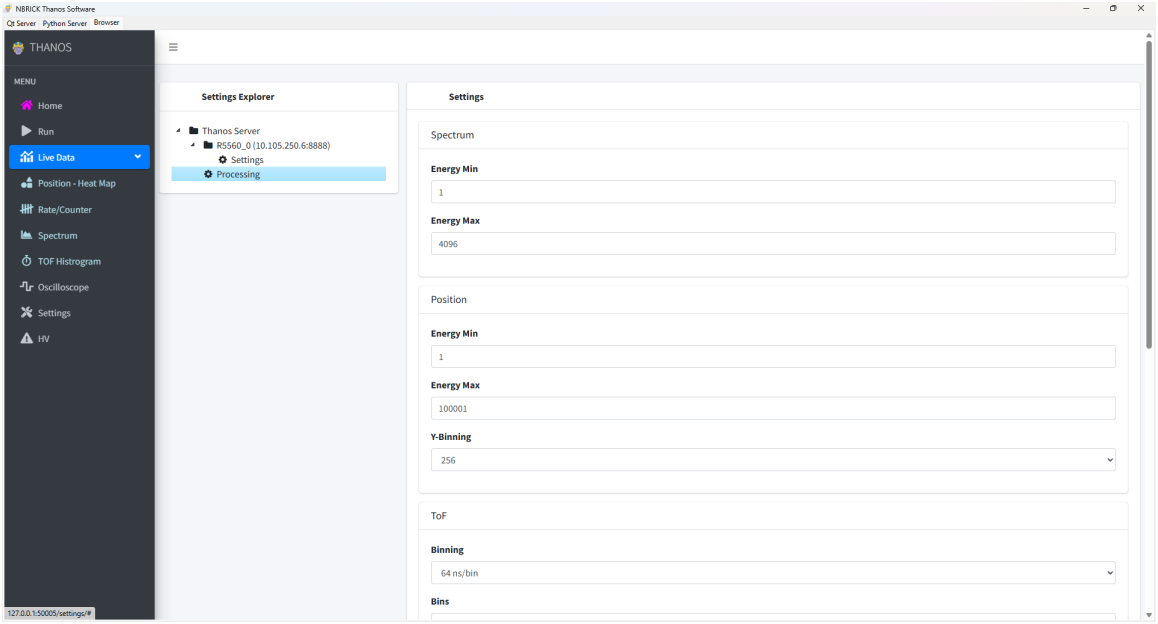


Fig. 4.69: Thanos Processing windows - Spectrum and Position panels.

The first panel ”Spectrum” allows users to define the maximum and minimum energy values displayed in the Spectrum plot (see Sec. **4.2.3.3**).
The second panel ”Position” allows to define the maximum and minimum energy values of the Position - Heat Map, and it also provides a drop-down menu to select the Y-axis binning among 64, 128, 256, 512, 1024 and 2048 bit (see Sec. **4.2.3.1**).

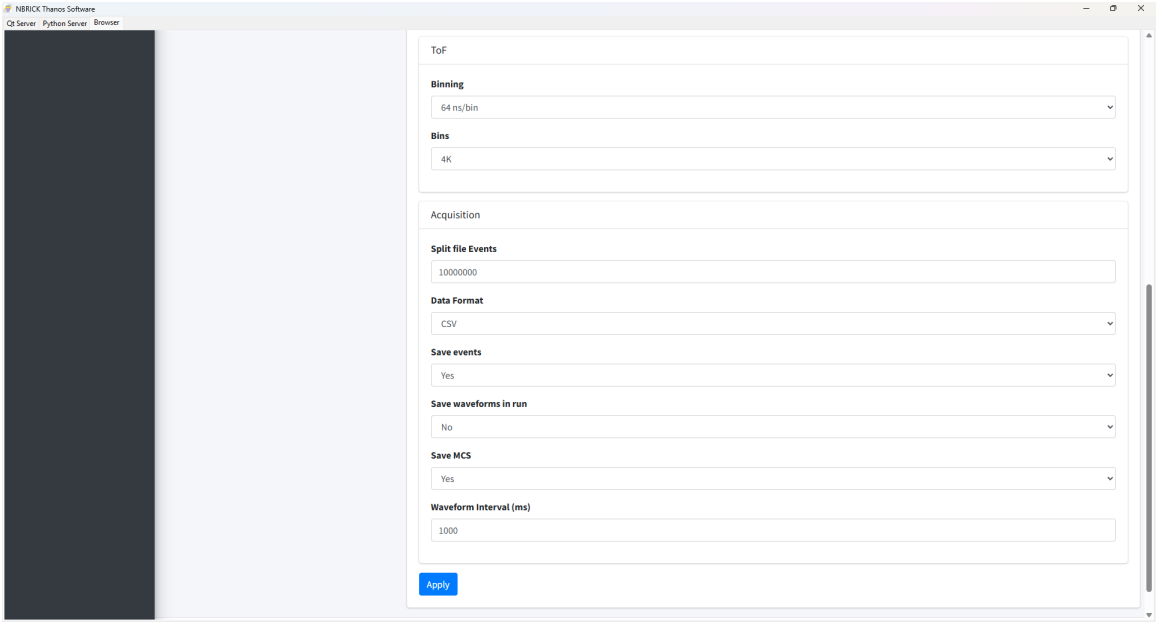


Fig. 4.70: Thanos Processing windows - ToF and Acquisition panels.

The third panel, labeled ”ToF”, allows users to configure two key parameters of the Time-of-Flight (ToF) histogram (see Sec. **4.2.3.4**):

- **Binning**: defines the time length of each bin, referred to the full-scale value set in the following field, ”Bins”. Available options are shown in Fig **4.71**.

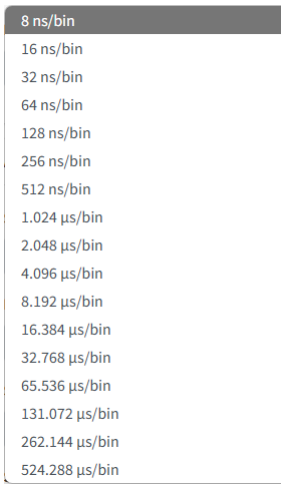


Fig. 4.71: Thanos ToF time length bin options.

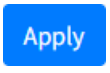
- **Bins**: set the maximum number of bins for the histogram. Users can choose among 1K, 4K, 16K and 65K.

Together, these two parameters determine the maximum time window that can be displayed in the ToF histogram.

Note: The selected binning values only represent the actual time length per bin if the ToF Histogram full-scale range matches the number of bins defined in the ”Bins” field. Users should be aware that modifying the binning parameters in the ”ToF” tab will automatically cause the software to recalculate the time length of each bin, ensuring consistency with the chosen number of bins.

The fourth panel, labeled ”Acquisition”, provides several configuration options related to the files generated during a run (see Sec. **4.2.2**):

- **Split file Events**: defines the maximum number of data rows stored in each ”dumper” file. Once this number is reached, a new file is automatically created.
- **Data Format**: allows users to select the file format for both ”dumper” and ”oscilloscope” files. Available formats include JSON, CSV, and Binary.
- **Save events**: enables or disables the saving of event data during a run.
- **Save waveforms in run**: allows users to choose whether to save waveform data during the run.
- **Save MCS**: enables the saving of a file containing rate and counts information during the acquisition.
- **Waveform Interval (ms)**: specifies in milliseconds (ms) the elapsed time between the saving of two consecutive waveforms. This field accepts only integer values greater than zero.

Note: To confirm any changes to the settings, users must press the 

button at the end of the dashboard.

Thanos will ask the user to restart the software (Fig. **4.72**).

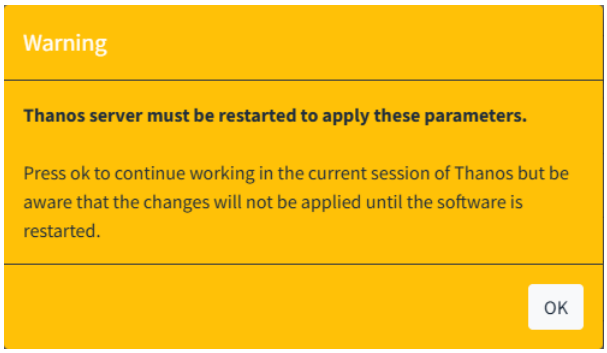


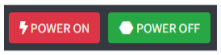
Fig. 4.72: Thanos relaunch request to finalize the changes.

Click "*OK*" to continue with the current session of Thanos, but be aware that changes will only be applied after restarting Thanos.

Note: Every time Thanos is restarted, all enabled HV channels will be automatically ramped down.

4.2.6 HV tab

The ”HV” tab allows users to manage and monitor the R8033DP HV Power Supply.

The control bar located in the upper-right corner 

includes buttons to power ON/OFF the enabled HV channels.

Fig. **4.73** shows the HV tab with all channels powered off. The dashboard consists of twelve columns, providing real-time status and control options for each HV channel:

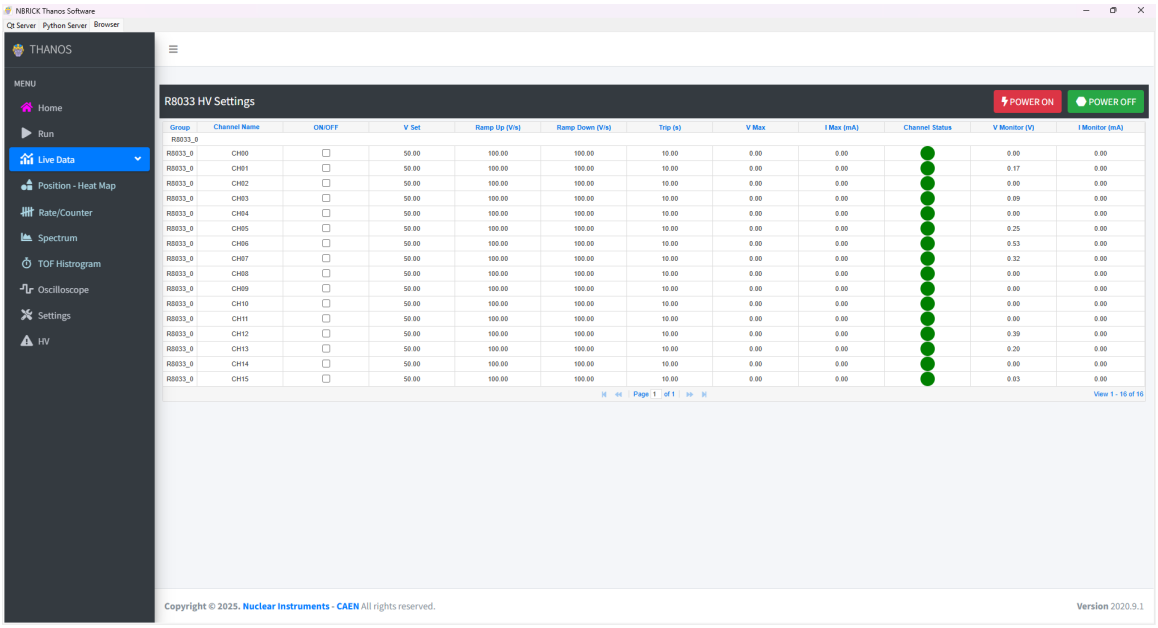


Fig. 4.73: Thanos HV tab with all channels powered off.

- **Group**: identifies the R8033 HV Power Supply connected.
- **Channel Name**: specifies the HV channel.
- **ON/OFF**: a button that allows users to power on/off the corresponding channel.
- V_{SET}: allows users to set the voltage for each channel. Enter the value and press the ”*Enter*” button on the PC keyboard. The maximum allowed value is 2000 V, as this is the highest value manageable by the R1443 pre-amplifier. Thanos prevents users from entering values above this limit.
- **Ramp Up (V/s)**: defines the voltage increase rate (in V/s) during the ramp-up. Possible range: 1 - 500 V/s in 1 V/s steps. Thanos prevents users from entering values above this limit.
- **Ramp Down (V/s)**: defines the voltage decrease rate (in V/s) during the ramp-down. Possible range: 1 - 500 V/s in 1 V/s steps. Thanos prevents users from entering values above this limit.
- **Trip (s)**: defines the TRIP value (in s). For more details, refer to Tab. **4.2**.
- V_{MAX}: specifies the maximum voltage limit for each channel.
- I_{MAX} **(mA)**: sepicifies the maximum current limit for each channel.
- **Channel Status**: displays the current status of each channel (more details on possible statuses in Sec. **4.2**).
- **V Monitor (V)**: displays the monitored high voltage provided by each channel.
- **I Monitor (mA)**: displays the monitored current drawn by each channel.

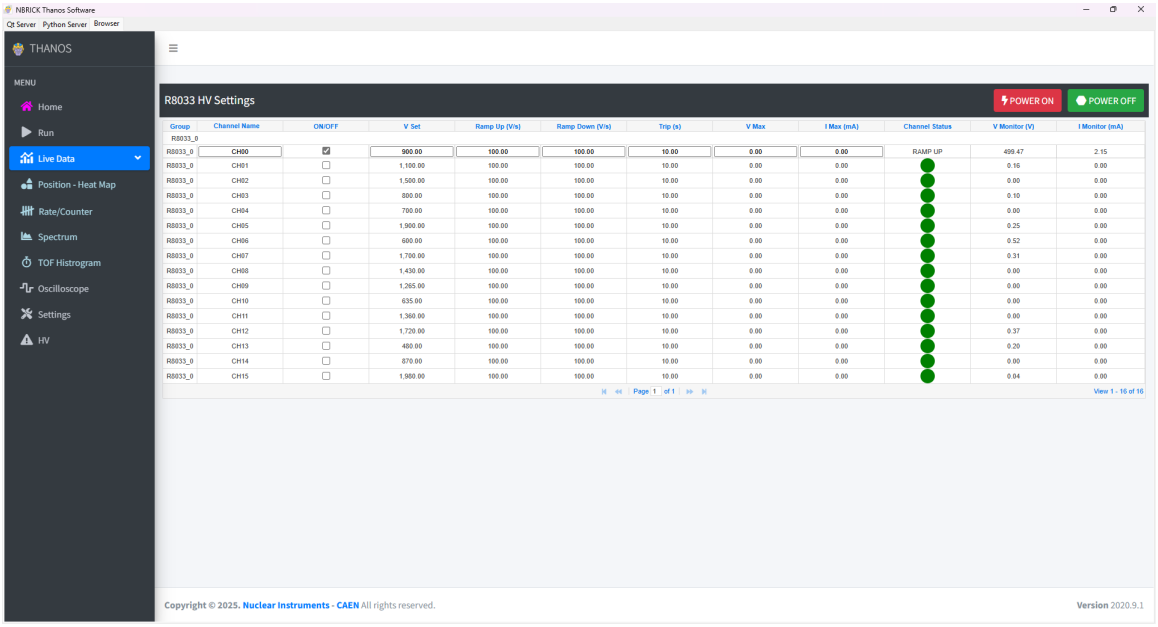


Fig. 4.74: Thanos HV - Only the first channel is ramping up.

Thanos allows users to control the HV channels individually. Fig. **4.74** shows an example where only the first channel is enabled and ramping up to its V_{SET} value.

To enable all the HV channels, check all the buttons in the ON/OFF column and then press  button to turning them on (Fig. **4.75** shows an example of channels ramping up).

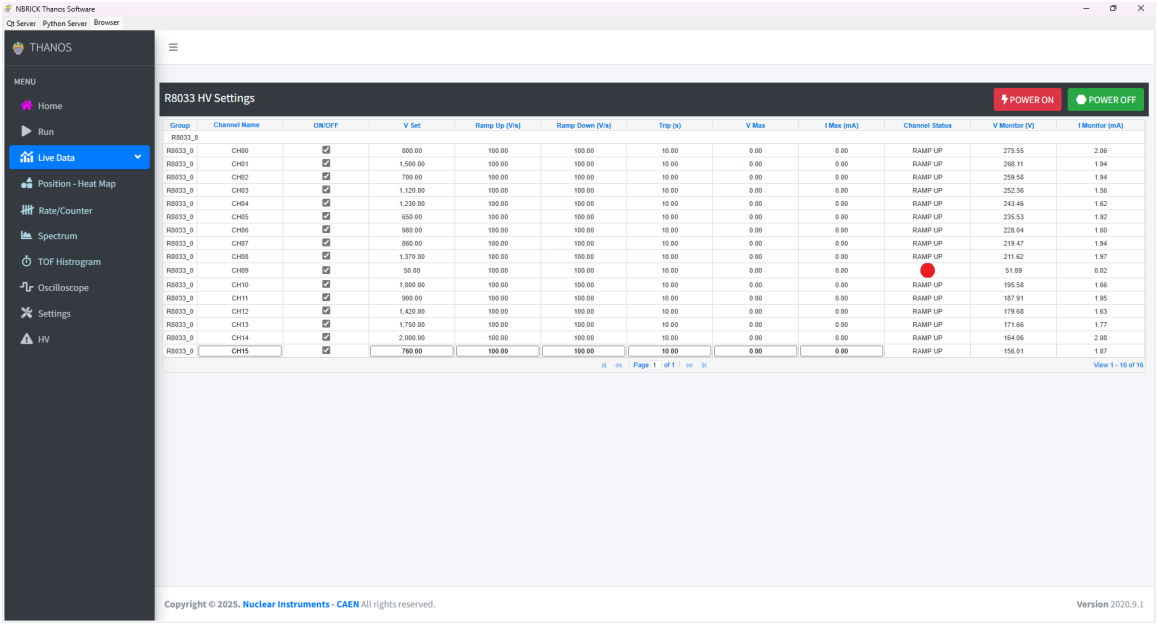


Fig. 4.75: Thanos HV tab with channels powering on.

If the HV Power Supply is in POWER ON status (verifiable in the ”Detector Status” panel under the ”Home” tab, see Sec. **4.2.1**), individual channel can be ramped up or down by checking the corresponding ON/OFF button in the column.

Note: Users should be aware that commands sent to the HV board may not be received immediately. During the update of HV settings, a status screen is displayed (Fig. **4.76**) indicating that the settings are being applied. It is recommended to avoid making rapid consecutive changes to the HV parameters, allowing sufficient time for the board to properly receive and process each command.

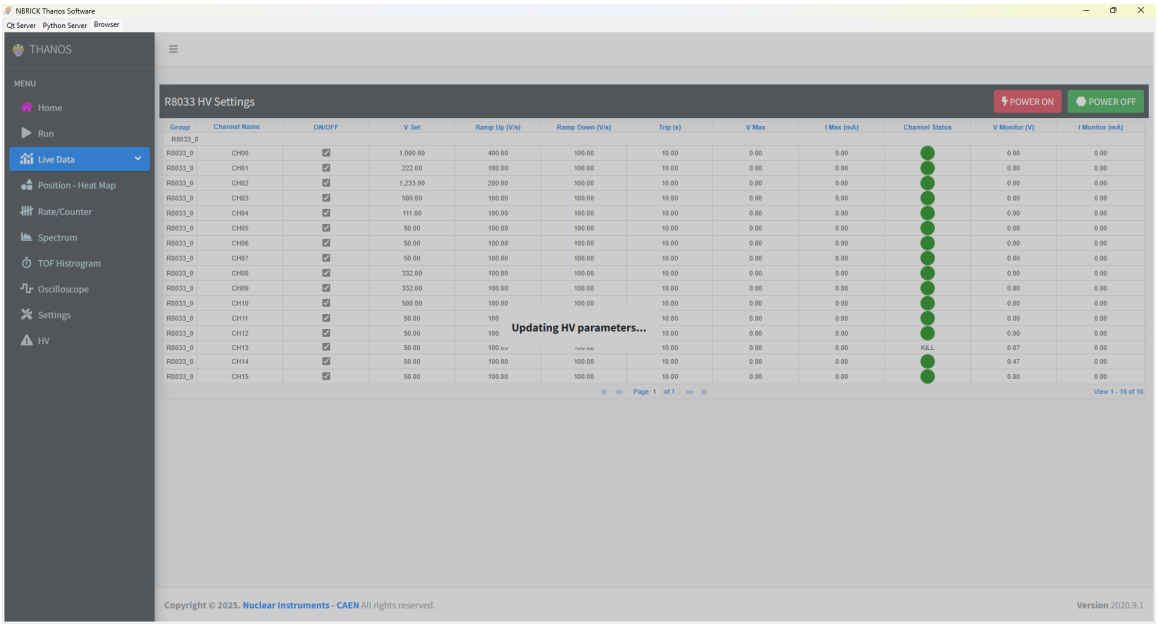


Fig. 4.76: Thanos updating HV parameters.

Note: Every time Thanos is restarted, all enabled HV channels will be automatically ramped down.

Fig. **4.77** shows an example of channels turning off.

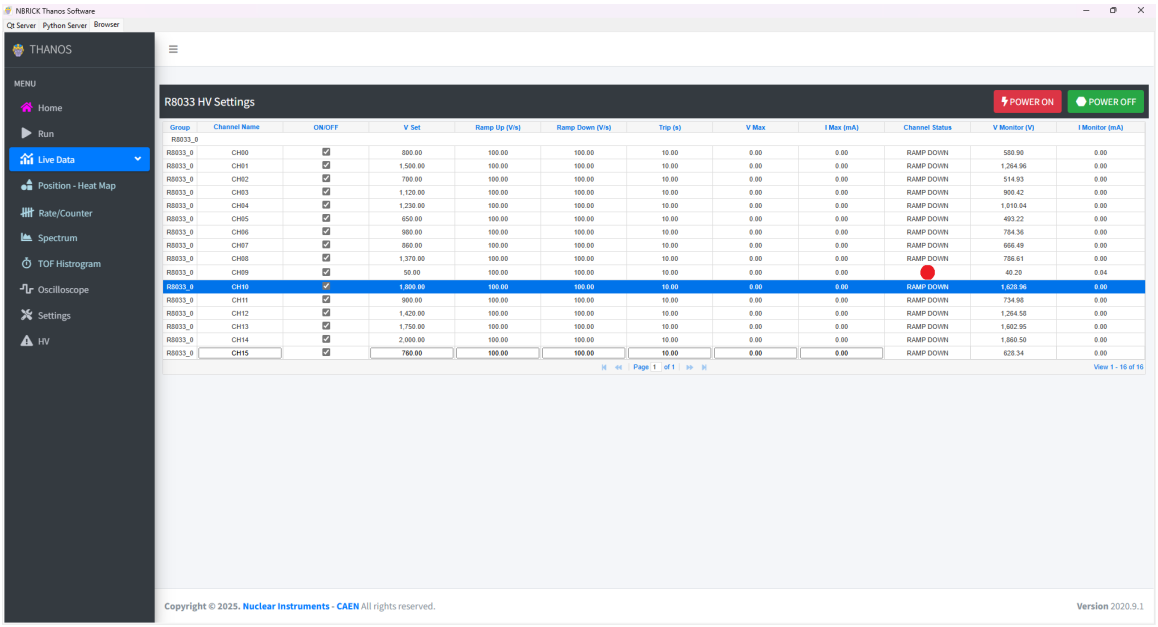


Fig. 4.77: Thanos HV tab with channels powering off.

HV CHANNEL STATUSES

The following table lists the main HV channel status messages and their meanings:

STATUS	MEANING
OFF	**OFF** (🟢): the channel is turned OFF.
ON	**ON** (🔴): the channel is turned ON.
RAMP UP	**RAMP UP**: the channel is increasing voltage up to the set value.
RAMP DOWN	**RAMP DOWN**: the channel is decreasing voltage to the set value.
OVER CURRENT	**OVER CURRENT**: a **Warning** condition where the detected current is higher than the set current.
OVER VOLTAGE	**OVER VOLTAGE**: when the detected voltage meets the following condition: $V_{MON} > V_{SET} + (2\% \text{ of } V_{SET}) + 2V$
UNDER VOLTAGE	**UNDER VOLTAGE**: when the detected voltage meets the following condition: $V_{MON} > V_{SET} - (2\% \text{ of } V_{SET}) - 2V$
TRIP	**TRIP**: the channel is powered off due to a TRIP condition. It represents the maximum time an ”overcurrent” condition can last (in seconds). If the ”Overcurrent” persists beyond the set TRIP value, the channel will shut down and voltage will drop to zero either at the ramp down rate or at the fastest available rate, depending on Power Down setting. TRIP range goes from 0 to 999.9 s with a step of 0.1 s; 1000 s = INFINITE (the ”overcurrent” condition persists indefinitely).
OVER POWER	**OVER POWER**: the output power is higher than the maximum allowed limit.
TEMP. WARNING	**TEMPERATURE WARNING**: when the detected temperature is high but below 65°.
OVER TEMP.	**OVER TEMPERATURE**: when the detected temperature is above 65°.
KILL	**KILL**: the channel is turned off via KILL from the front panel or back panel.
INTERLOCK	**INTERLOCK**: the channel in INTERLOCK condition via front panel or back panel. When INTERLOCK is active, channels are turned off at the fastest available rate, regardless the RAMP DOWN setting. To reset the Interlock flag, all switches must be placed on KILL and then on OFF.
DISABLED	**DISABLED**: the channel is disabled.
FAIL	**FAIL**: Generic failure detected.
LOCK	**LOCK**: the channel control switch is set to ON/EN and at least one of the following conditions is TRUE: • Power On in local mode. • Switch from remote to local.
MAXIMUM VOLTAGE	**MAXIMUM VOLTAGE**: the detected voltage is higher than the maximum limit set via trimmer (see Sec. **2.1**).

Tab. 4.2: HV channel statuses table.

Note: Overvoltage, overcurrent, and interlock protections ensure safe operation of the HV system. For more details about the R8830C HV Power Supply functionalities, please refer to the 803x Series Power Supply User Manual **[RD1]**.

Fig. **4.78** displays an example of different channel's statuses.

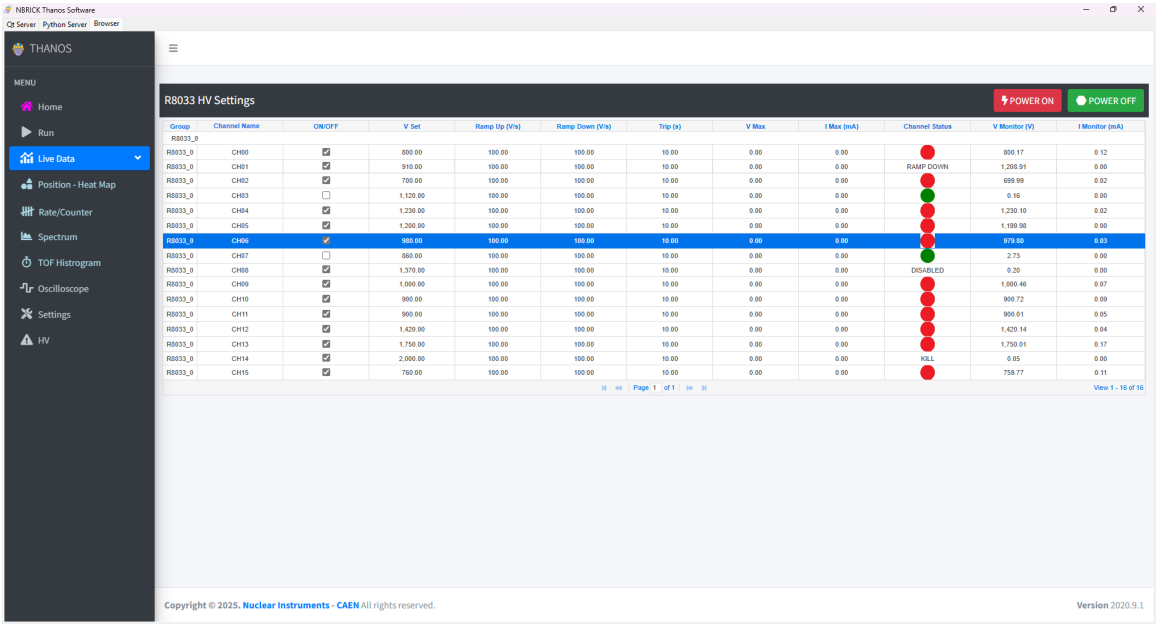


Fig. 4.78: Thanos - Example of different channel statuses.

4.2.7 Qt and Python Servers

This system is designed to operate as a remote-managed server, supporting multi-client access. Its architecture is optimized for setups where data acquisition and control are handled from external clients connected over the network.

The local web interface is intended primarily for monitoring purposes, especially in cases where the system is used in single-client or standalone mode. However, the full potential of the system lies in its ability to function as a central server, with multiple clients remotely managing and interacting with it.

Note: Although the system supports multi-client connectivity, only one client can actively control the server at a time. Concurrent access is limited to maintain data integrity and ensure stable performance.

The window labeled “Qt Server” displays the acquisition log, capturing real-time messages from the process. The “Python Server” window, on the other hand, shows the log of the backend web server, providing insight into the communication and processing handled by the Python-based web interface.

Fig. 4.79: Thanos Qt Server window.

In essence, these logs give users visibility into the internal operations of both the acquisition system and the web-based control layer, which is particularly useful for debugging, monitoring performance, or diagnosing issues during remote operation.

4.3 Troubleshooting

In some cases, the main configuration file of Thanos ”thanos_config_qdcpos.json”, located in the Thanos software folder on the user’s PC, may become corrupted. When this occurs, Thanos will display a warning window, as shown in Fig. **4.80**.

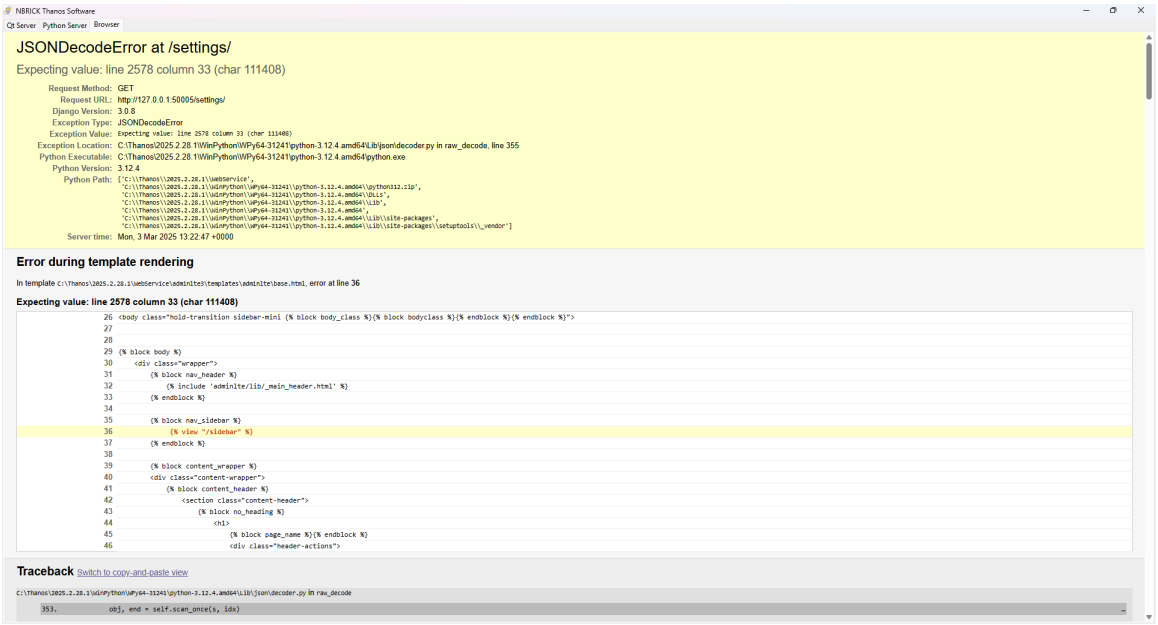


Fig. 4.80: Thanos - Window displayed if the main configuration file becomes corrupted.

To resolve this issue, restart the Thanos software, which will initiate the restoration process to default settings. Upon restarting, an error message (Fig. **4.81**) will inform the user that the configuration file is corrupted.

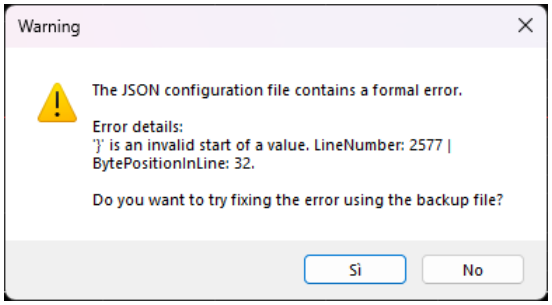


Fig. 4.81: Thanos - Error message informs the user that the configuration file is corrupted.

If the user wishes to attempt restoring the configuration using a backup file, they should click on ”*Yes*”. A confirmation message will then appear, informing the user that the existing configuration file will be entirely replaced with the backup one, resulting in the loss of any previously modified settings (Fig. **4.82**). Before proceeding, users may choose to manually save their current settings. Click on ”*Yes*” to replace the corrupted file.

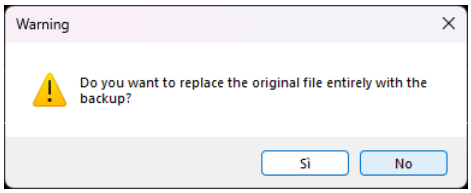


Fig. 4.82: Thanos - Warning message informs the user that the previous modified settings will be lost.

Once the restoration process is successfully completed, a final message will appear (Fig. **4.83**). Users must restart Thanos to resume normal operation and continue with the data acquisition and analysis.

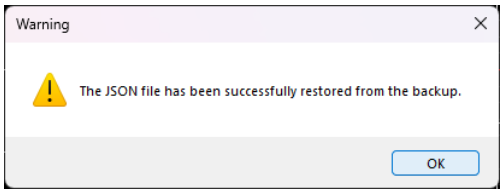


Fig. 4.83: Thanos - Message informs users that the restoring process succeeds.

If the user choose to not replace the corrupted configuration file with the backup, an informational message will appear, followed by an error message (Fig. **4.84** and **4.85** respectively).

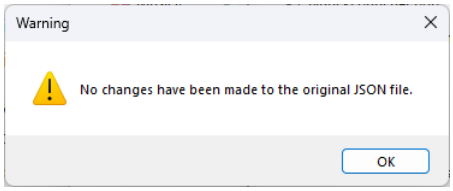


Fig. 4.84: Thanos - Message infroms the user that the configuration file has not been replaced.

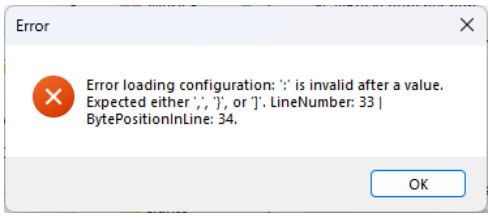


Fig. 4.85: Thanos - Error message.

In this case, users may attempt to manually repair the corrupted file or save specific settings before proceeding. Regardless of the chosen approach, the restoration procedure can always be restarted by relaunching Thanos software.

5 Web Interface

The R5560C comes with an embedded web interface that allows the user to upload new firmware and upgrade the instrument OS.

To connect to the web interface:

- Connect the instrument to the PC via Ethernet or USB. It is possible to connect the baseboard or the DAQ board using the dedicated connection ports of each section.
- If using Ethernet, set your PC to be in the same network of the instrument.
- Open a web browser and type the IP or USB address as shown on the instrument display, according to the chosen physical connection (IP refers to Ethernet connection).

Note: For neutron detection applications using the CAEN NBrick system, updating the **DAQ** firmware is essential, as the Thanos software relies on it for data acquisition. However, the **Baseboard** is not managed by Thanos. The following section describes how to connect to the Baseboard for updating the OS version running on the processor, only if necessary.

5.1 Baseboard Web Interface

Connection

To access the specific Web Interface of the baseboard, connect to the board by using the Ethernet port as shown below.

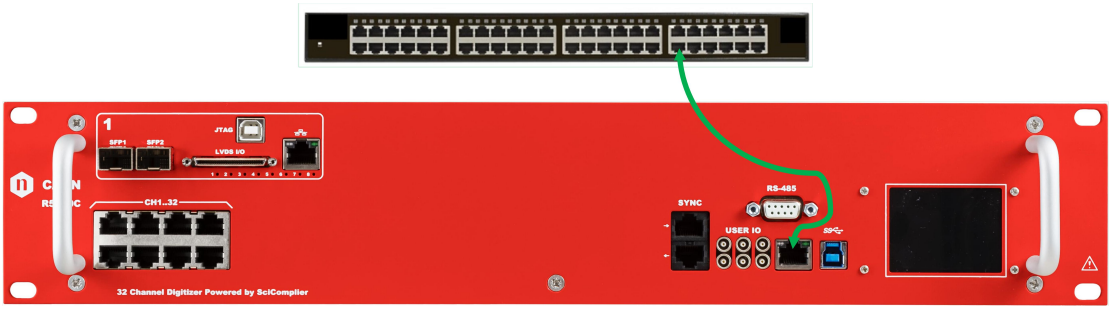


Fig. 5.1: Connection scheme to access the baseboard Web Interface. The baseboard port can be connected to the network or directly to a PC Ethernet port.

Device status and firmware upgrade

In the Device Status (Home) window it is possible to monitor:

- the board IP address
- the board PID
- the temperature of the baseboard
- the baseboard firmware release (i.e. the OS of the system)
- the IP of the DAQ board
- the firmware loaded on the DAQ board (name and release)

- the temperature of the DAQ board
- the temperature of the analog board

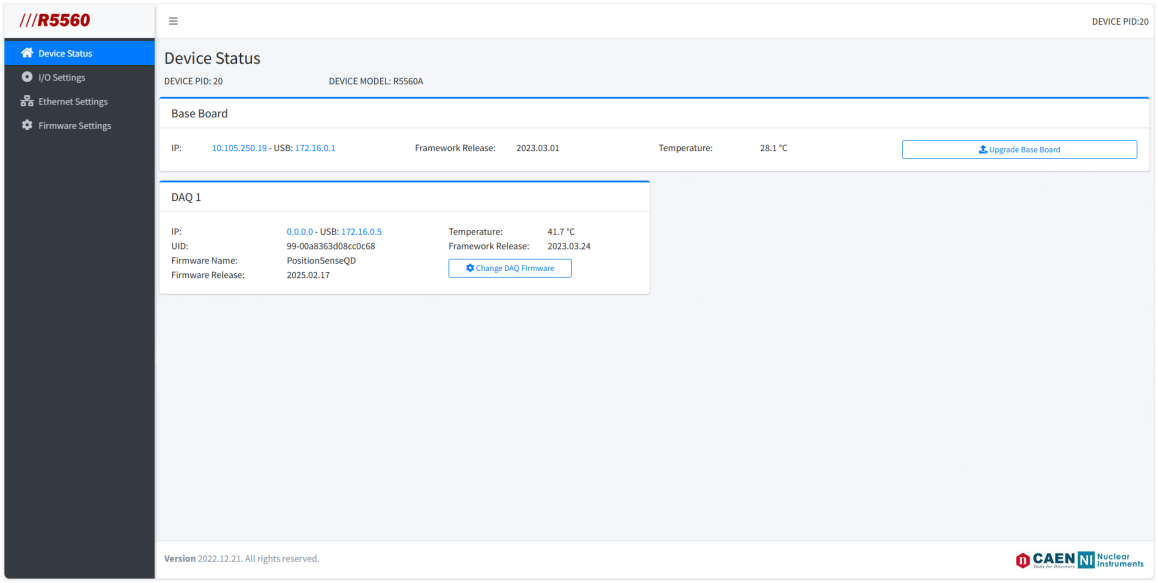


Fig. 5.2: The Home page of the baseboard Web Interface.

If a newer version of the OS running on the ARM processor is released on the CAEN website, it is possible to upgrade the device by clicking on "*Upgrade Base Board*". The opening page will ask the user to select a **.bsu file** previously downloaded from the CAEN website. Press "*Upgrade*" button to perform the loading of the new OS version and follow the given instructions.

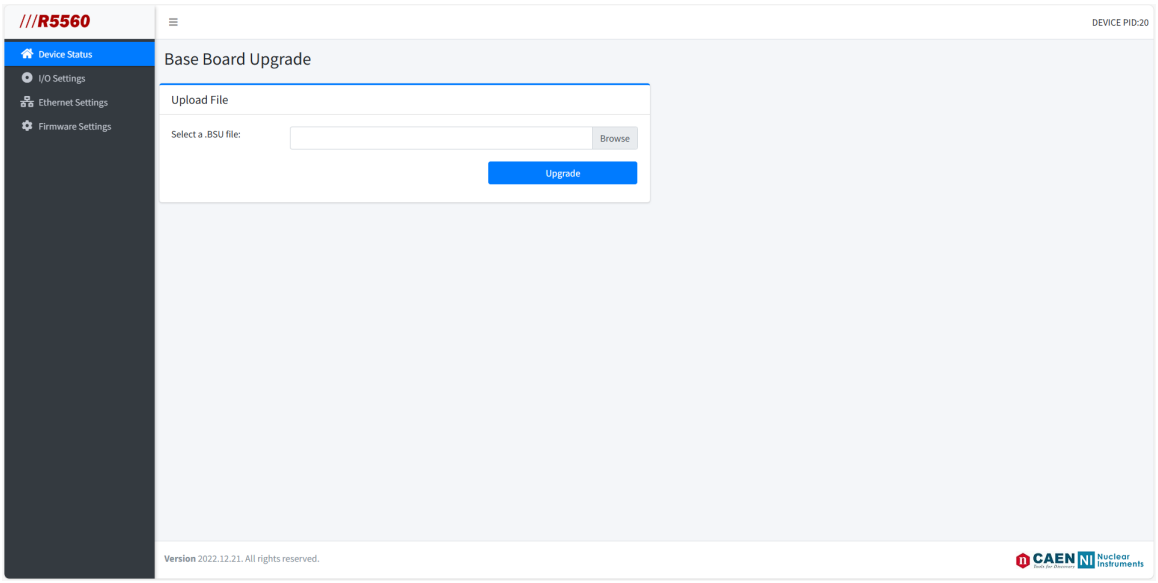


Fig. 5.3: Upgrade of the OS of the board from the baseboard Web Interface.

Firmware Settings

The Firmware Settings window allows the user to manage the **FPGA firmware** to be loaded into the DAQ section. Once the DAQ is selected, it is possible to load firmware already installed onboard (choose from the drop-down menu and press "*Install*") or to upload a new **.niu file**.

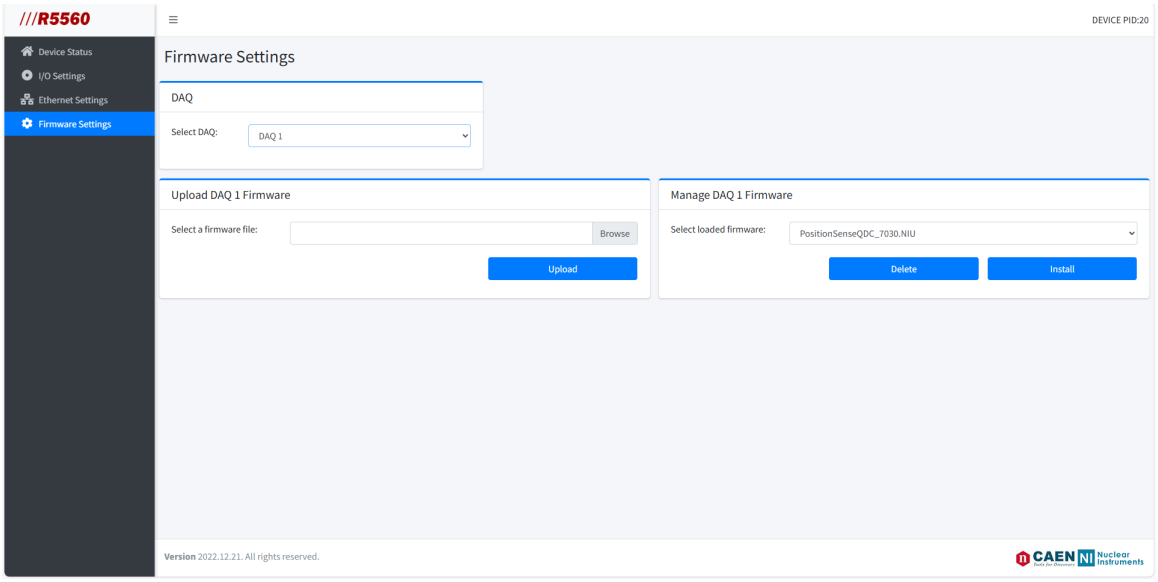


Fig. 5.4: The Firmware Settings page of the baseboard Web Interface.

5.2 DAQ section Web Interface

Connection

To access the DAQ Web Interface, connect to the board using the Ethernet ports as shown below (Fig **5.5**).

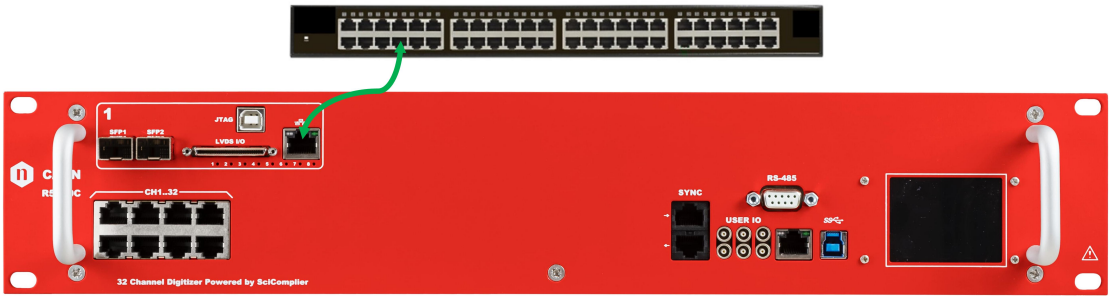


Fig. 5.5: Connection scheme to access the DAQ section Web Interface. The DAQ section port can be connected to the network or directly to a PC Ethernet port.

Device status and firmware upgrade

In the Device Status (Home) window (Fig. **5.6**), users can monitor:

- the DAQ board IP address.
- the FPGA UID.
- the temperature of the DAQ board.
- the Framework release (i.e. the system's OS version).
- the firmware loaded on the DAQ board (name and release).
- Connection information for base and DAQ.

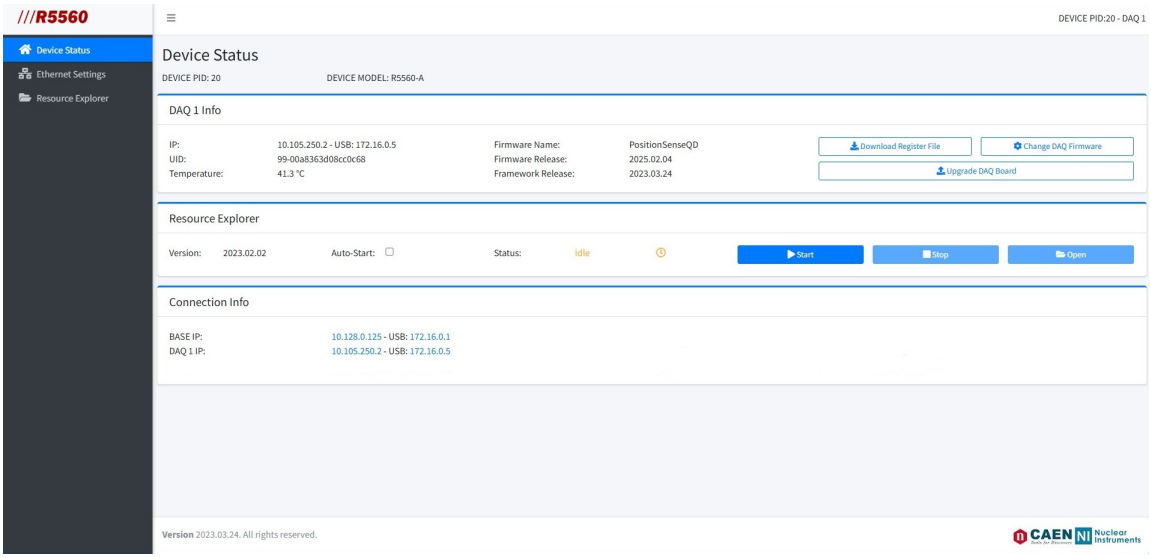


Fig. 5.6: Home page of the DAQ section Web Interface.

If a new OS version for the ARM processor is released on the CAEN website, it is possible to upgrade the device by clicking on "*Upgrade DAQ Board*". The opening page (Fig. **5.7**) will ask the user to select the **.dqsu** file previously downloaded from the CAEN website. Press "*Upgrade*" button to perform the loading of the new OS version and follow the given instructions.

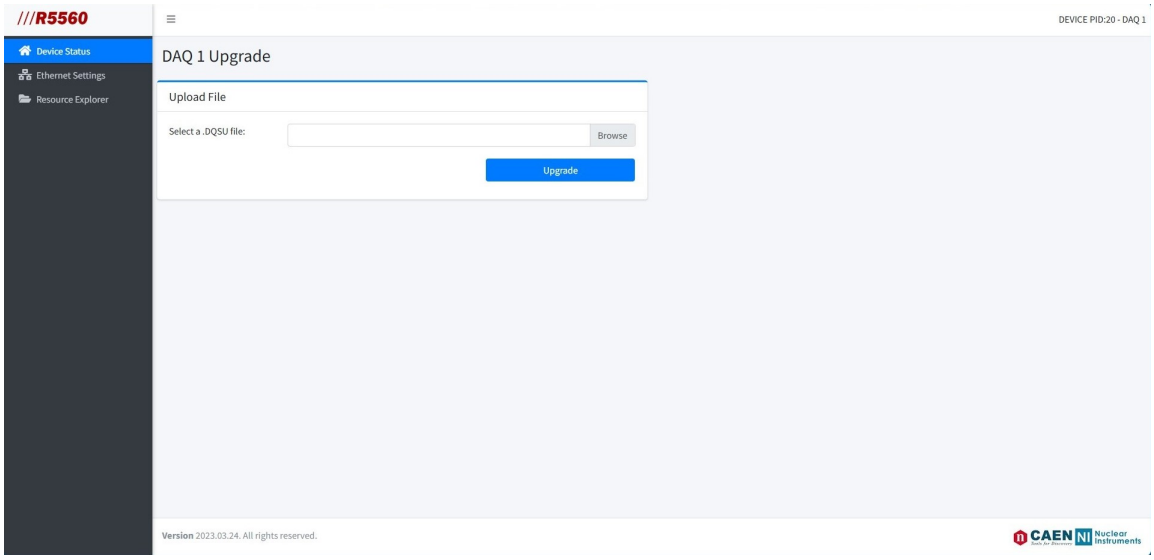


Fig. 5.7: Upgrade of the OS of the board from the DAQ Web Interface.

To upload a new DAQ firmware, press "*Change DAQ Firmware*" button in the DAQ section. In the opening page (Fig. **5.8**), it is possible to load a firmware already installed onboard (choose from the drop-down menu and press "*Install*") or to upload a new **.niu** file. In this last case press "*Browse*", choose the new firmware to upload and then left click on "*Upload*". The firmware will be copied in the persistent memory of the R5560C.

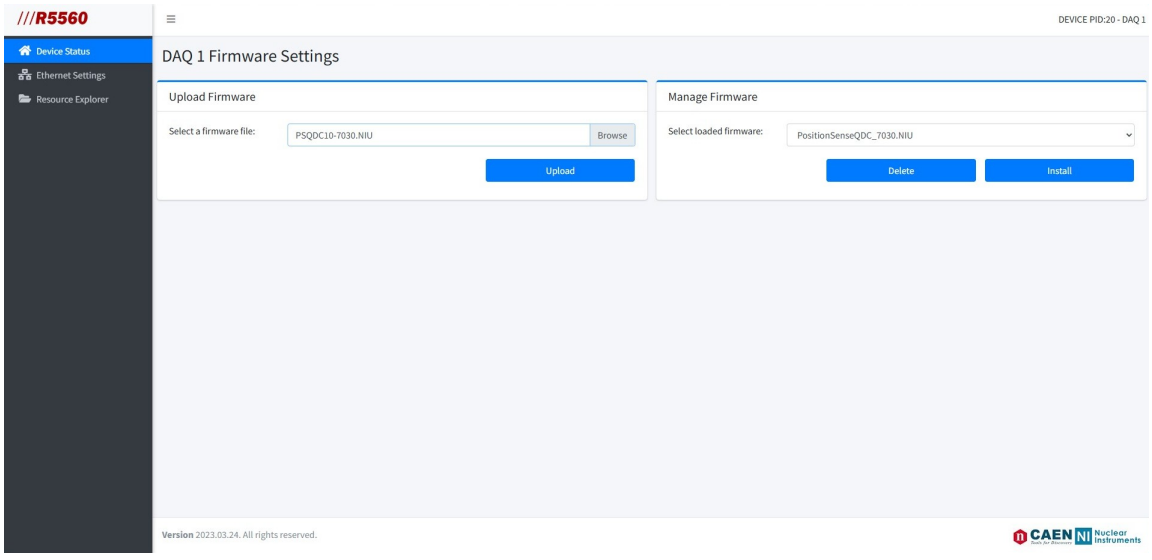


Fig. 5.8: Upgrade of the firmware from the DAQ section Web Interface.

It is now possible to activate the firmware by selecting its name in the Manage Firmware drop-down menu and press "*Install*" button (Fig. **5.9**).

The confirmation message "Firmware installed successfully" will appear in the "Manage Firmware" tab (Fig. **5.10**).

After the reboot of the DAQ, update the webpage to complete the procedure. The new firmware is now activated.

It is also possible to remove an existing firmware by selecting its name in the scroll-down menu and press

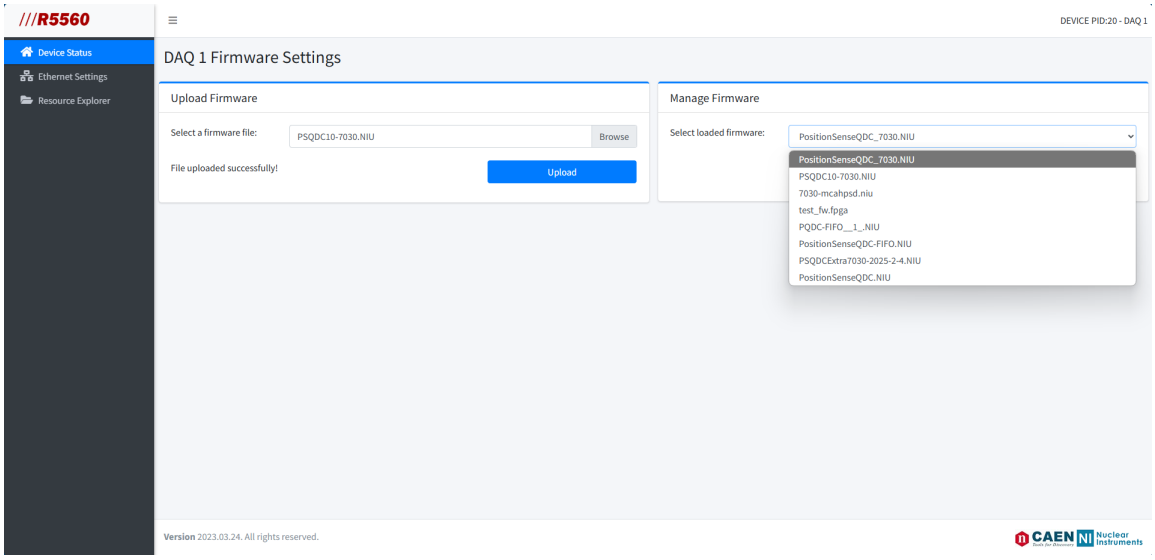


Fig. 5.9: Activate the firmware from the DAQ section Web Interface.

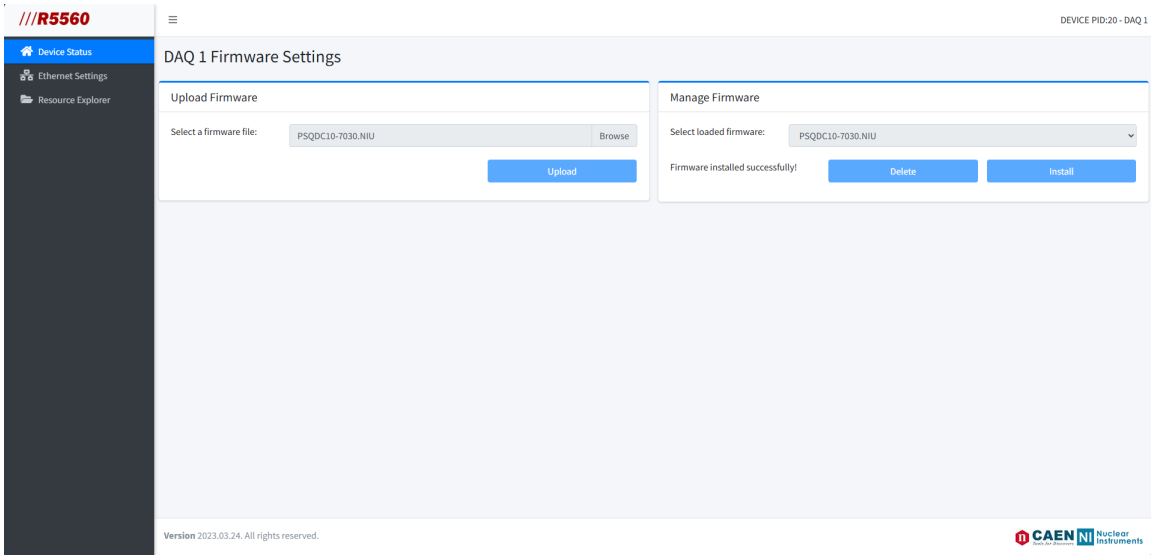


Fig. 5.10: Firmware successfully installed message.

"*Delete*" button. For any of this operation, follow the instructions given in the subsequent opening windows and always check if a successful info message appears.

Note: if upgrading the firmware via USB, follow the procedure below to avoid Windows USB peripheral recognition problems:

- Change the firmware and let the unit reboot automatically as per the standard process.
- Disconnect the USB cable.
- Reboot the module manually.
- Reconnect the USB and the unit should be correctly seen in the Device Manager as Remote NDIS Compatible Device.

Ethernet Settings

The Ethernet Settings window (Fig. **5.11**) allows the user to configure the IP address of the DAQ section. It is possible to enable the DHCP in order to automatically obtain an IP address from the DHCP server in the network, or to manually assign the IP address by clicking on the keyboard icon on the right.

Assign an IP in a valid range for your network in order to be able to reach the instrument from your computer. For example, if your computer IP address is a 10.128.1.1, type an IP that ranges from 10.128.1.2 to 10.128.1.254 and the mask (NM) must be 255.255.255.0

After modifying the Ethernet settings, press "*Apply*" button and follow the instructions given in the opening window.

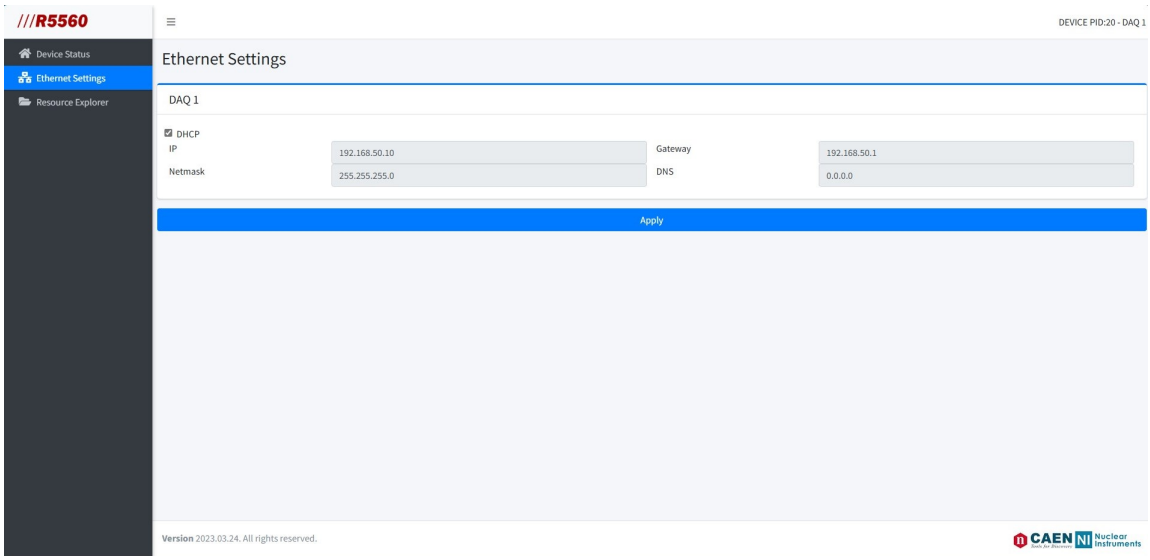


Fig. 5.11: The Ethernet Settings page of the DAQ section Web Interface.

6 Instructions for Cleaning

The equipment may be cleaned with isopropyl alcohol or deionized water and air dried. Clean the exterior of the product only.
Do not apply cleaner directly to the items or allow liquids to enter or spill on the product.

6.1 Cleaning the Touchscreen

To clean the touchscreen (if present), wipe the screen with a towelette designed for cleaning monitors or with a clean cloth moistened with water.
Do not use sprays or aerosols directly on the screen; the liquid may seep into the housing and damage a component. Never use solvents or flammable liquids on the screen.

6.2 Cleaning the Air Vents

It is recommended to occasionally clean the air vents (if present) on all vented sides of the board. Lint, dust, and other foreign matter can block the vents and limit the airflow. Be sure to unplug the board before cleaning the air vents and follow the general cleaning safety precautions.

6.3 General Cleaning Safety Precautions

CAEN recommends cleaning the device using the following precautions:

- Never use solvents or flammable solutions to clean the board.
- Never immerse any parts in water or cleaning solutions; apply any liquids to a clean cloth and then use the cloth on the component.
- Always unplug the board when cleaning with liquids or damp cloths.
- Always unplug the board before cleaning the air vents.
- Wear safety glasses equipped with side shields when cleaning the board.

7 Device Decommissioning

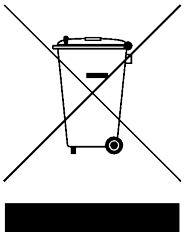
After its intended service, it is recommended to perform the following actions:

- Detach all the signal/input/output cable
- Wrap the device in its protective packaging
- Insert the device in its packaging (if present)

THE DEVICE SHALL BE STORED ONLY AT THE ENVIRONMENT CONDITIONS SPECIFIED IN THE MANUAL, OTHERWISE PERFORMANCES AND SAFETY WILL NOT BE GUARANTEED

8 Disposal

The disposal of the equipment must be managed in accordance with Directive 2012/19 / EU on waste electrical and electronic equipment (WEEE).



The crossed bin symbol indicates that the device shall not be disposed with regular residual waste.

9 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/safety-information-product-support

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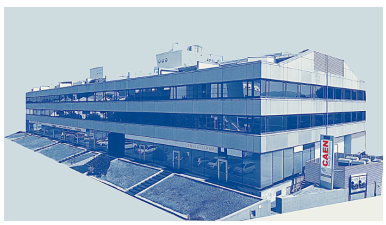

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