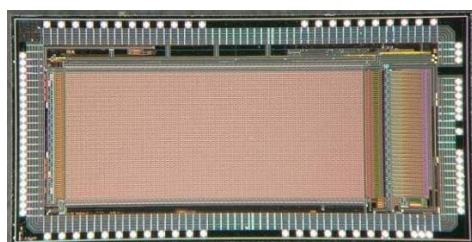


WaveCatcher Software User's Manual



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WaveCatcher Software User's Manual

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V/Ref. : 1.1

This User's Manual contains the full description of the WaveCatcher Family Control & Readout software. The latter is compatible with the 2-channel (with revised firmware) and 8-channel WaveCatcher modules, the 16-Channel WaveCatcher board and module, and all the options of the 64-Channel WaveCatcher Crate (16, 32, 48 or 64 channels).

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WaveCatcher Software User's Manual

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1 Introduction

The WaveCatcher systems are a family of **powerful and low cost digitizers**. Their number of channels currently ranges between 2 and 64 (+8) channels.

They all make use of the **SAMLONG** analog memory chips which permit sampling the input signal between 400 MS/s and 3.2 GS/s over 12 bits and with a signal bandwidth of 500 MHz.

There are 4 different types of systems:

- **2-channel**, USB-powered handy module
- **8-channel** (autonomous desktop), composed of a motherboard equipped with two 4-channel mezzanines
- **16-channel** (6U board or autonomous desktop module)
- **64-channel** (mini crate). This crate can actually house between 1 and 4 16-channel boards, thus providing **16, 32, 48 or 64 channels**.

From the second version of the 16-channel boards on, 2 extra channels have been added in the back of the board. They can be digitized together with the other channels. When the board is used in standalone mode, these channels correspond to the external trigger and the external sync. Otherwise, they are equivalent to other channels.

The boards can also be used as **TDCs** for high precision time measurement between two signals. Sampling time precision after calibration is indeed **less than 5 ps rms** at 3.2GS/s.

The systems are currently interfaced with a 480 Mbits/s USB link. A secured Gbit UDP interface is also available on the 8-channel module. It will soon be put into function on the 64-channel systems. An optical link (all systems) will also be put into function but later.

For a complete description of the hardware, see the associated documentation: **WaveCatcher Family User's Manual** which can be found at

<https://owncloud.lal.in2p3.fr/public.php?service=files&t=56e4a2c53a991cb08f73d03f1ce58ba2>

in the **System documentation** folder.

Software access to the WaveCatcher systems can be performed in two ways:

1. Via a **high-level software library**, available on Windows or Linux. The latter can be found at

<https://owncloud.lal.in2p3.fr/public.php?service=files&t=56e4a2c53a991cb08f73d03f1ce58ba2>

in the **Library** folder.

Full documentation can be found in the **Documentation** folder of the library.

2. Via a **dedicated powerful software** running on Windows, described in this document. The latter can be found at

<https://owncloud.lal.in2p3.fr/public.php?service=files&t=56e4a2c53a991cb08f73d03f1ce58ba2>

in the **Software** folder.

There is no low-level library.

2 System description

2.1 Global description of the WaveCatcher systems

The WaveCatcher boards and modules are 12-bit 3.2 GS/s Switched Capacitor Digitizers issued from the collaboration between CEA/IRFU & CNRS/IN2P3/LAL and based on the SAMLONG chip[1], developed on the basis of a CEA/IRFU and IN2P3/LAL common patent [2].

The input dynamic range is 2.5 Vpp (DC coupled) and the input standard is single ended MCX coaxial connectors. The DC offset is adjustable in the ± 1.25 V range via a 16-bit DAC on each channel. The signal analog bandwidth is 500 MHz @3dB.

Considering the sampling frequency and the number of bits, it is well suited for very fast signals as the ones generated by fast scintillators or crystals coupled to PMTs, MCP-PMTs, Silicon Photomultipliers, APD, Diamond detectors and others.

The analog input signals are continuously sampled inside the SAMLONG chips in a circular analog memory buffer (1024 cells) at the default sampling frequency of 3.2 GS/s (312.5 ps of sampling period); 6 other frequencies down to 0.4 GS/s are also selectable via software. As a trigger signal arrives, all analog memory buffers are frozen and subsequently digitized with a resolution of 12 bits into a digital memory buffer with independent read and write access. Up to 7 full events per channel (1 event = 1024 words of 12 bits) can be stored consecutively.

Each input channel is equipped with a discriminator using a 16-bit programmable threshold, which generates trigger primitives. Primitives from all channels are processed by the board to generate a common trigger causing all the channels to acquire an event simultaneously. The common board trigger can also be provided externally via a software command, or via the front panel TRIGIN input connector, or by any combination of the channel discriminators and/or the TRIGIN.

During analog to digital conversion process, the WaveCatcher cannot handle other triggers, and thus generates a dead time (maximum 125 μ s, decreasing proportionally with the recording depth thanks to the configurable record length).

Each pair of channels is equipped with a 40-bit TDC (counter) tagging the trigger with the clock delivered to the SAMLONG chips (200 MHz down to 25 MHz depending on the selected sampling frequency).

Each input channel is equipped with a hit rate monitor based on its own discriminator and on two counters giving the number of hits which cross the programmed discriminator threshold (also during the dead time period) and the time elapsed with a 1 MHz clock. This permits among others measuring the hit rate with respect to the signal amplitude.

Each input channel is also equipped with a digital measurement block located in the front-end FPGA which permits extracting in real time all the main features from the signal: baseline, peak, charge, time of the edges in CFD or fixed threshold modes.

Each channel houses a fixed amplitude pulser, which permits an easy complete functionality test and the use of the module in reflectometer mode.

The module supports multi-board synchronization allowing all SAMLONG chips to be synchronized with a common clock source and ensuring triggering them in phase. All data will then be aligned and coherent between multiple WaveCatcher boards.

All WaveCatchers house USB 2.0 which allows data transfers up to 30 MB/s. The 8-channel module and 64-channel crate also provide a secured Gbit UDP interface. In addition, all the boards house an Optical Link but the latter has not yet been put in function.

2.2 Global description of the WaveCatcher software

The WaveCatcher software has been developed in order to take an easy benefit of all the features described in § 2.1. It permits performing real time measurements and histograms on the acquired data and to save it on disk with numerous options in ASCII or binary format.

The main panel looks like the front panel of a digital oscilloscope. This permits an easy hand taking.

The C code has been written with the NI CVI LabWindows environment tool. It makes use of the NI Run Time.

Binary to ROOT data converters are also available in the eponym folder.

3 Installing the WaveCatcher software

This software can be downloaded at:

<https://owncloud.lal.in2p3.fr/public.php?service=files&t=56e4a2c53a991cb08f73d03f1ce58ba2>

in the *Software* folder. It has to be fully installed the first time. Then only the executable has to be replaced for the next updates, except if new dlls have been released. In the latter case, they also have to be replaced.

4 Running the WaveCatcher software

4.1 Launching the software

When launching the software, the first panel appearing is shown on **Figure 4.1**.

First select between USB and UDP depending on the bus you chose for the connection.

If USB has been chosen, all the boards detected will be listed. Select the one you want to connect to and click on *Connect/Reset*.

If UDP has been chosen, check the IP address and port of the module. Once they are ok, click on *Connect/Reset*.

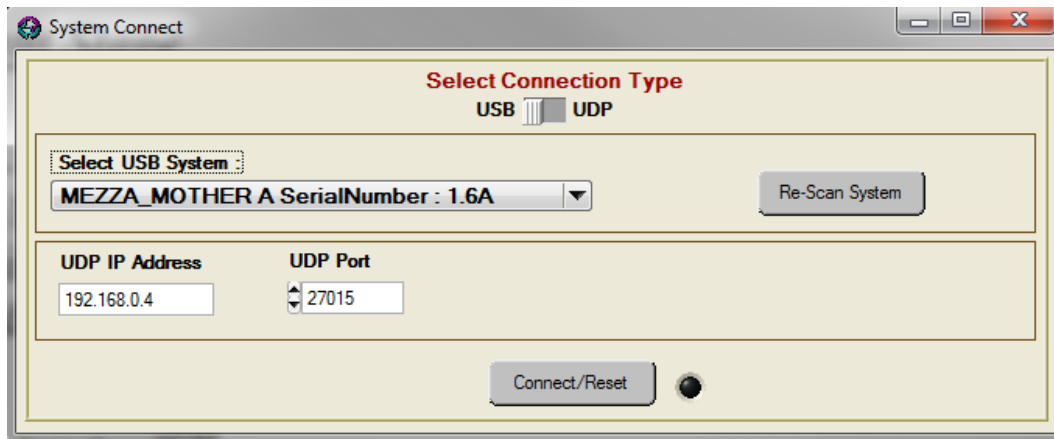


Figure 4.1: System Connect window

4.2 Main panel

Once the board or module is connected, the software proceeds to the initialisation. It reads the board's EEPROMs and loads all the registers and DACs. Once this done, the main panel is displayed (see Figure 4.2).

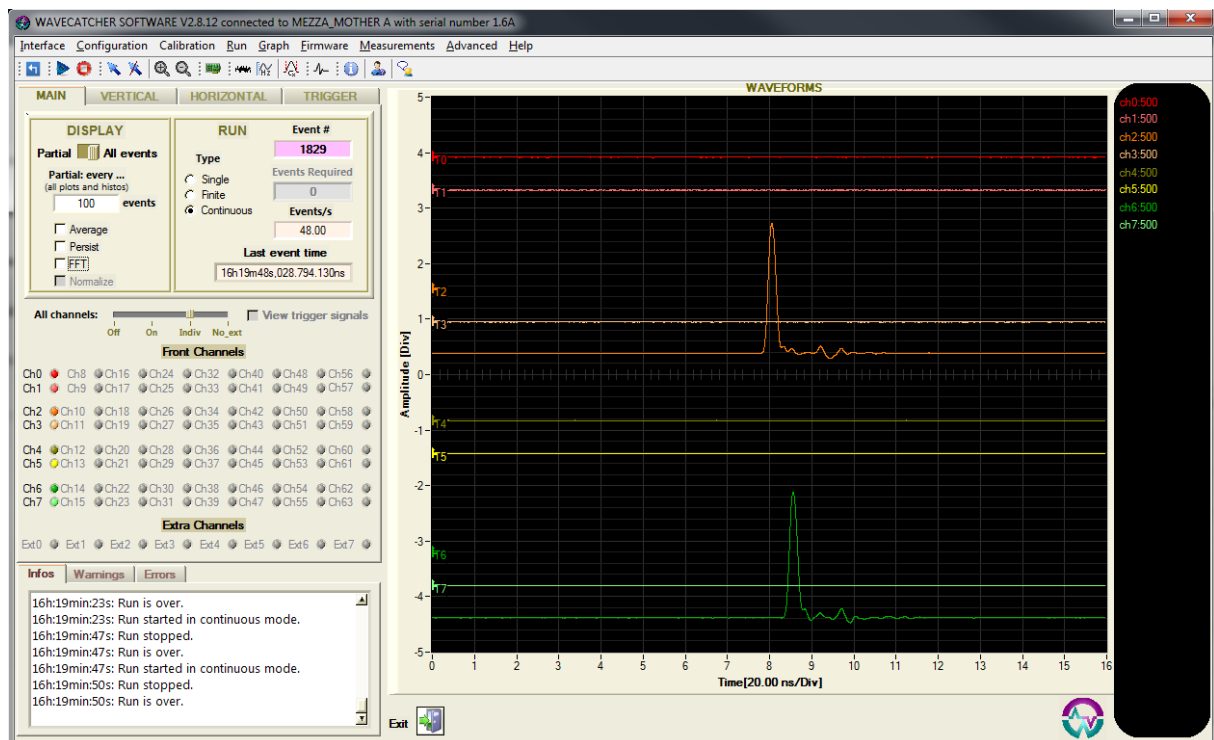


Figure 4.2: Main Panel

A report on the initialisation phase can be found in the *Infos* message window. The same information is saved in a log file in the directory where the software has been launched.

The interface is split between 5 main areas:

1. The menus at the top
2. The icons right below
3. The graphical tabs on the left
4. The waveform histogram on the right
5. The message window on the bottom left

They will all be described in the following chapters.

5 THE MENUS

5.1 Interface menu

This menu permits performing a Global Reset of the system or exiting the software.

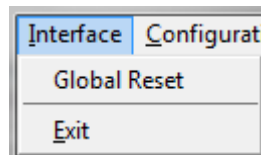


Figure 5.1: *Interface menu*

5.2 Configuration menu

This menu permits setting up the configuration of the system. It concerns the Setup (both software and hardware), the options for data saving on disk, and the configuration of the UDP interface.

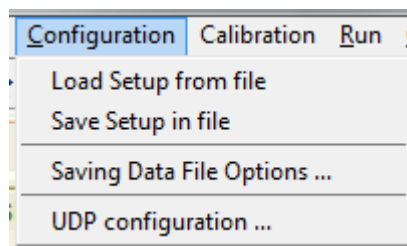


Figure 5.2: *Configuration menu*

- **Load Setup from file:** by clicking on this item in the menu, the user opens a Windows Directory window from where a Setup Configuration previously stored in a dedicated file can be retrieved and used to reconfigure the WaveCatcher system accordingly.

Warning: the version of the software is stored with the configuration. When loading a previously saved setup, the software checks if the current version number corresponds to that stored in the file. If the versions are not compatible, the setup is not loaded and a message is displayed accordingly. The same way, the software checks if the systems and number of boards in the system are the same.

- **Save Setup in File:** by clicking on this item in the menu, the user opens a Windows Directory window where the current Setup configuration can be stored in a dedicated file whose name is defined by user.
- **Saving Data File Options:** by clicking on this item in the menu, the user opens a new window displayed on **Figure 5.3**.
 - In the top field, the user can configure the file type (ASCII or Binary) and enable the data splitting to multiple files selecting the number of events per file.
 - In the middle field, the user can choose putting in the file the absolute Unix Event Time, as well as the raw channel hit rates.
 - In the bottom field, the user can choose to filter the channels based on their absolute peak amplitude. Only the channels with an absolute peak amplitude higher than the defined threshold will be saved on disk.

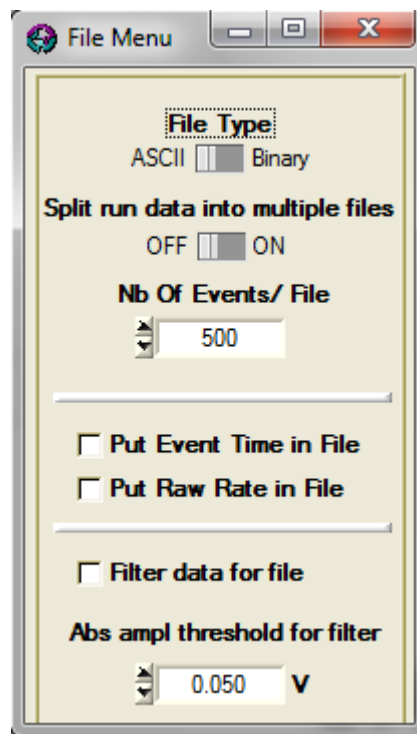


Figure 5.3: File menu

- **UDP configuration:** by clicking on this item in the menu, the user opens a new window displayed on
- **Figure 5.4.** There, the user can read or define the IP Address and the Port number stored in the system's EEPROM.

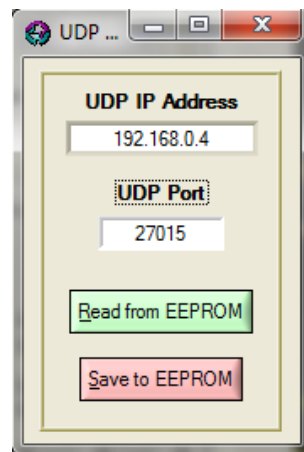


Figure 5.4: UDP configuration menu

5.3 Calibration menu

The main factory calibrations described in the hardware documentation (*WaveCatcher Family User's Manual*) are not accessible to the user since they don't vary with time:

- **Trigger Threshold DAC Offset Calibration:** this calibration is necessary to obtain the best precision for small signals on the trigger threshold for the channel input discriminator.
- **Line Offset Calibration:** this calibration makes use of 32 DACs located inside the SAMLONG chips. It permits reducing the baseline noise down to ~ 0.95 mV rms. With this sole calibration performed, waveform data is already directly usable with a dynamic range of 11.5 bits and a sampling time precision of ~ 20 ps rms.
- **Time INL Calibration:** this factory calibration which is optional compensates the fixed time dispersion along the sampling matrix. It makes use of a simple sinewave signal. The eventual sampling time precision scales down from ~ 20 ps rms to less than 5 ps rms.

The only accessible calibration remaining is the **Individual Pedestal Calibration**: this calibration permits reducing the baseline noise down to ~ 0.75 mV rms, thus increasing the dynamic range to 11.7 bits. It is advised to perform this calibration with a full setup and no signal present.

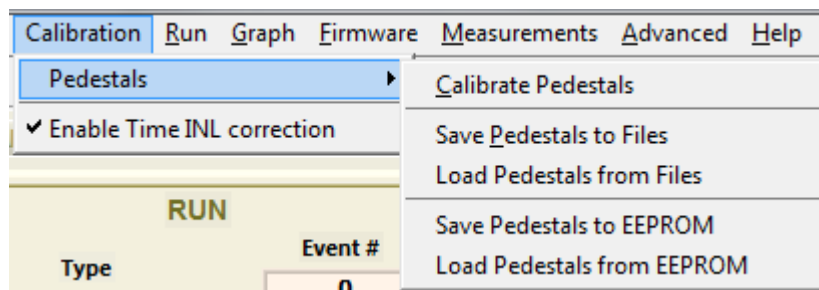


Figure 5.5: Calibration menu

The Calibration menu list is displayed on Figure 5.5.

- **Pedestals:** by clicking on this item in the menu, the user opens a secondary list:

- **Calibrate Pedestals:** by clicking on this item in the list, the user opens a new window displayed on **Figure 5.6**. The number of events for this calibration (300 is fine) has to be defined before clicking on ok.

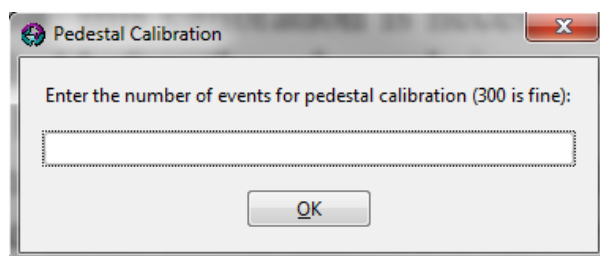


Figure 5.6: Pedestal Calibration window

- **Save Pedestals To Files:** by clicking on this item in the list, the user saves the individual pedestals to predetermined files.
- **Load Pedestals From Files:** by clicking on this item in the list, the user loads the individual pedestals from predetermined files.
- **Save Pedestals To EEPROM:** by clicking on this item in the list, the user saves the individual pedestals to the system EEPROM, which will be automatically readout at start-up.
- **Load Pedestals From EEPROM:** by clicking on this item in the list, the user loads the individual pedestals from the system EEPROM.

5.4 Run menu

This menu permits defining the configuration of the run and starting and stopping it. It is displayed on **Figure 5.7**.

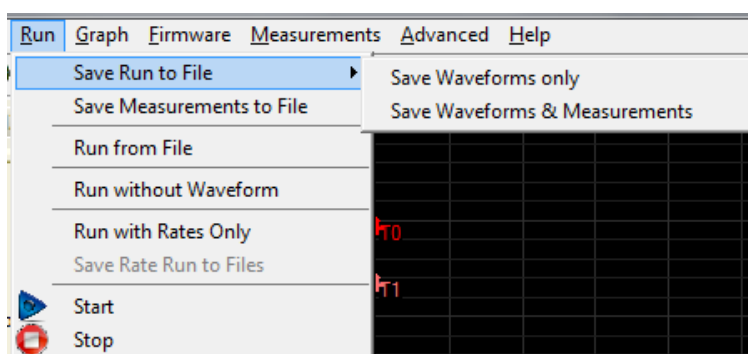


Figure 5.7: Run menu

- **Save Run to File:** by default, this item is dimmed. To undim it, select a **finite** number of events in the main tab. By clicking on this item in the menu, the user opens a secondary list:
 - **Save Waveforms only:** by clicking on this item in the list, the user chooses to save only the Waveforms in the files.
 - **Save Waveforms & Measurements:** by clicking on this item in the list, the user chooses to save both the Waveforms and the Measurements in the files.

- **Save Measurements to File:** by clicking on this item, the user chooses to save only the Measurements in the files.
- **Run from File:** by clicking on this item, the user chooses that the next run will be based on already recorded data. This option is not yet functional.
- **Run without Waveforms:** by clicking on this item, the user chooses that only the measurements are sent from the system to the computer. That way, no waveform is transmitted and the event rate increases drastically. Since the measurements are then performed by the firmware in the boards, the *Firmware Measurement Mode* is enforced and the corresponding parameters have to be checked. The waveforms are then displayed based on the firmware measurements as shown on **Figure 5.8**.

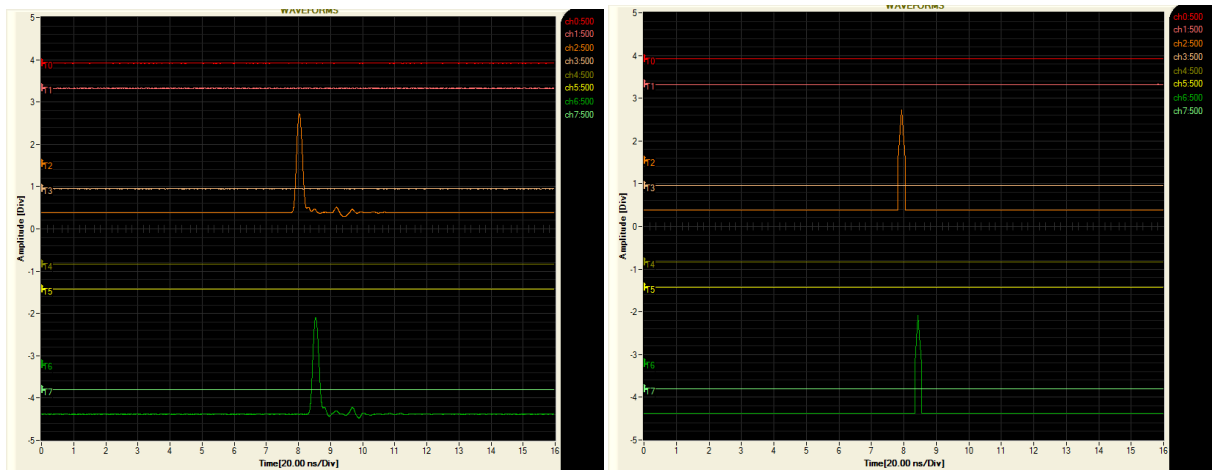


Figure 5.8: display for runs with (left) and without (right) Waveforms

- **Run with rates only:** by clicking on this item, the user selects a run where no signal is recorded or transmitted but only the channel hit rates. Clicking opens the *Rate Statistics* window (see § 5.7.2) where the rate measurement interval can be defined as well as all the other parameters relative to the rate measurements.
- **Start:** by clicking on this item, the user will start the run on all selected channels.
- **Stop:** by clicking on this item, the user will stop the current run.

5.5 Graph menu

This menu (see **Figure 5.9**) permits working on the displayed waveforms.

- **Enable Cursors:** by clicking on this item, the user will enable the display of the two bidirectional graph cursors.
- **Disable Cursors:** by clicking on this item, the user will disable the display of the two bidirectional graph cursors.
- **Zoom In:** by clicking on this item, the user will zoom to the area located inside the two bidirectional graph cursors.
- **Zoom Out:** by clicking on this item, the user will go back to the full waveform display.

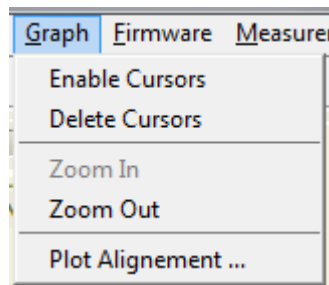


Figure 5.9: *Graph* menu

- Plot Alignment:** by clicking on this item, the user will have the possibility to resynchronize the waveforms based on digitized data the same way it is done in the digital oscilloscopes. The main consequence is that **display jitter is completely removed**. Once the option is checked ON, the present parameters will define the source of the resynchronization, the edge of the signal to be used, and the threshold level.

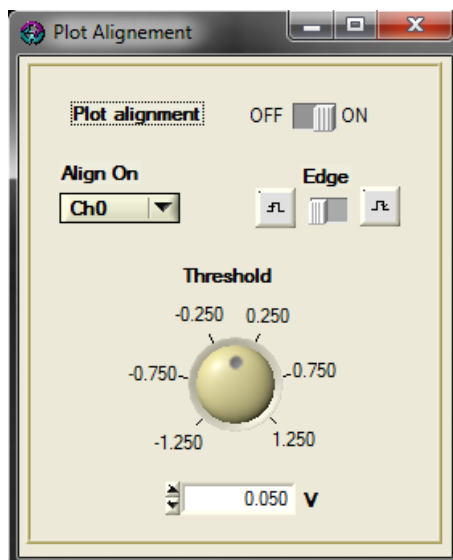


Figure 5.10: *Plot Alignment* window

5.6 Firmware menu

This menu (see **Figure 5.11**) simply permits reading out the firmware version of the elements of the connected system.

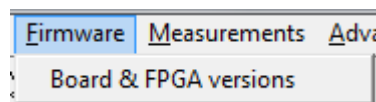


Figure 5.11: *Firmware* menu

5.7 Measurements menu

This menu (see **Figure 5.12**) permits selecting the type of measurements to be performed and their corresponding parameters.

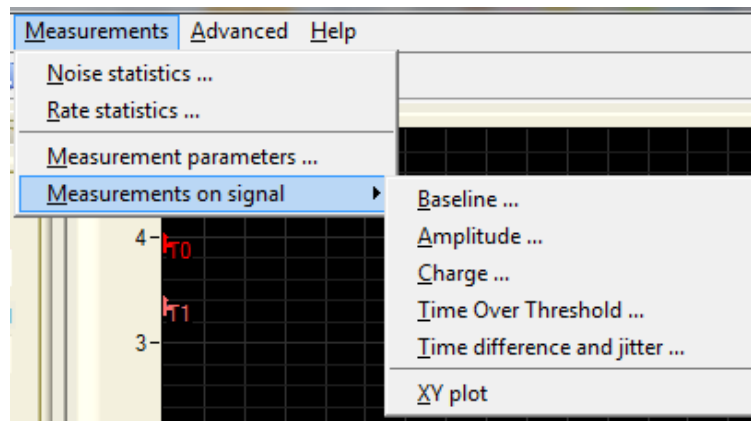


Figure 5.12: Measurements menu

5.7.1 *Noise Statistics window*

- **Noise Statistics:** by clicking on this item, the user opens an eponym window. In order to perform the measurement, the On/Off checkbox has to be checked.
 - **Compute Sigma in the graph window:** the two boxes fix the boundaries of the zone where the noise calculation will be performed.

Figure 5.13 shows the pedestal noise.

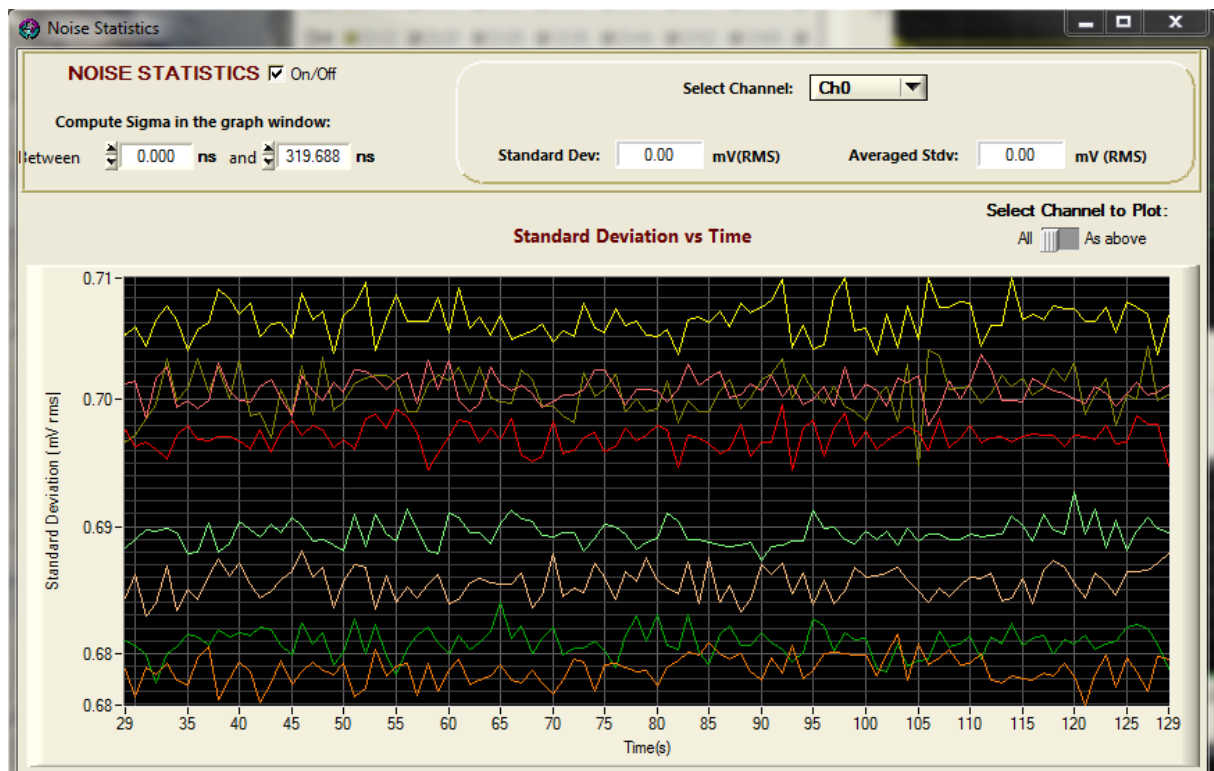


Figure 5.13: Noise Statistics window

5.7.2 *Rate Statistics window*

- **Rate Statistics:** by clicking on this item, the user opens an eponym window. In order to perform the measurement, the On/Off checkbox has to be checked. Each block of 4 channels contains 4 set of counters. The user can define coincidences between the 4 channels for feeding the 4 set of counters.
 - **Define coincidence for counters:** each column corresponds to a set of counters whose values will be associated to the channel with the same number when an event is readout. The optional coincidence between channels is defined vertically.
 - **Veto after counter increment:** by checking the **Enable Veto** box, the user can mask the counting during a time window defined by **Veto Length**. This permits for instance rejecting bothering after-pulses.
 - **Select source for rate counters:** the source for the rate counters can be either the raw output of the channel discriminators, or the same signal but spread by the trigger gate (see § 7.4).
 - **Interval between Measurements:** this option is used only when **Run with rates only** has been selected in the **Run** menu (see § 5.4).
 - **Plot one linear combination of two counters:** this option permits plotting the result of a linear combination of the rates of the two selected counters.

Figure 5.14 shows an example where the thresholds have been put in the noise.

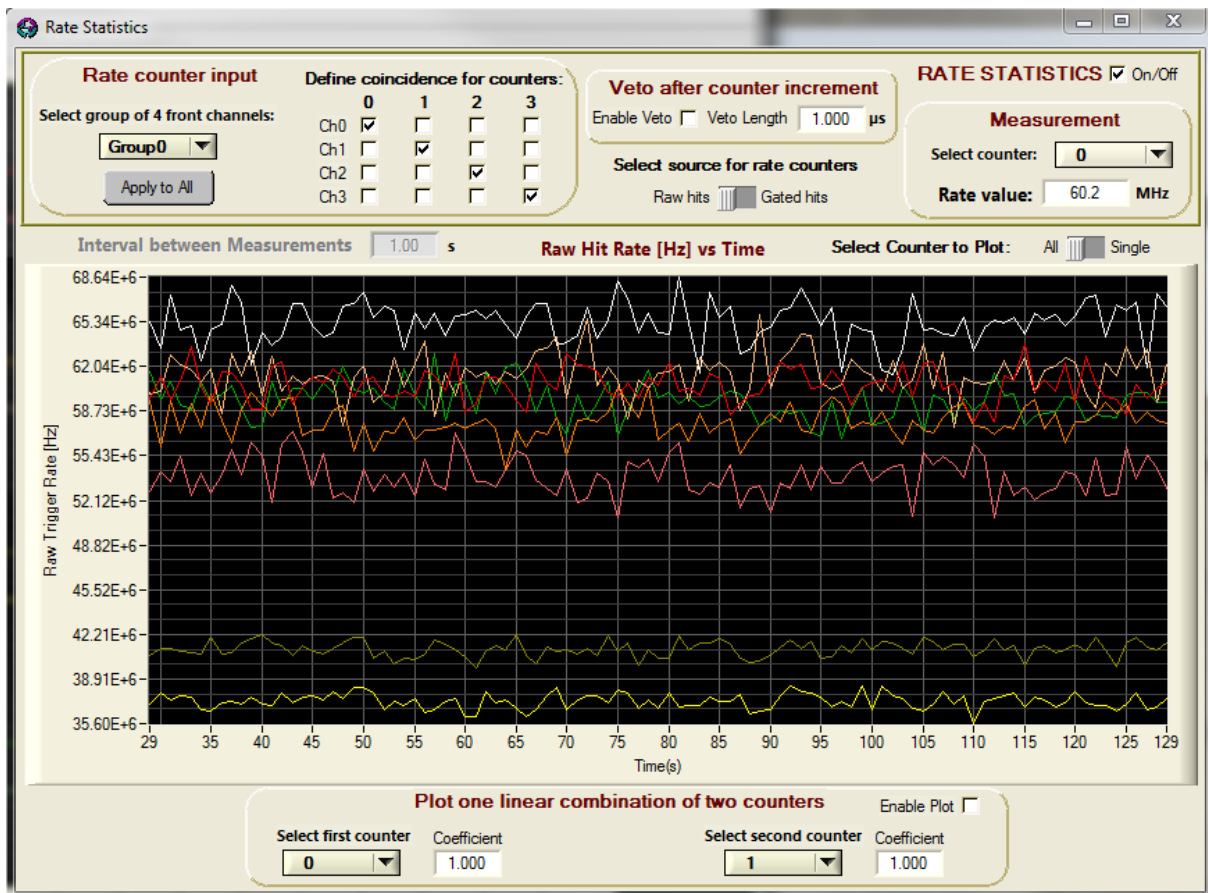


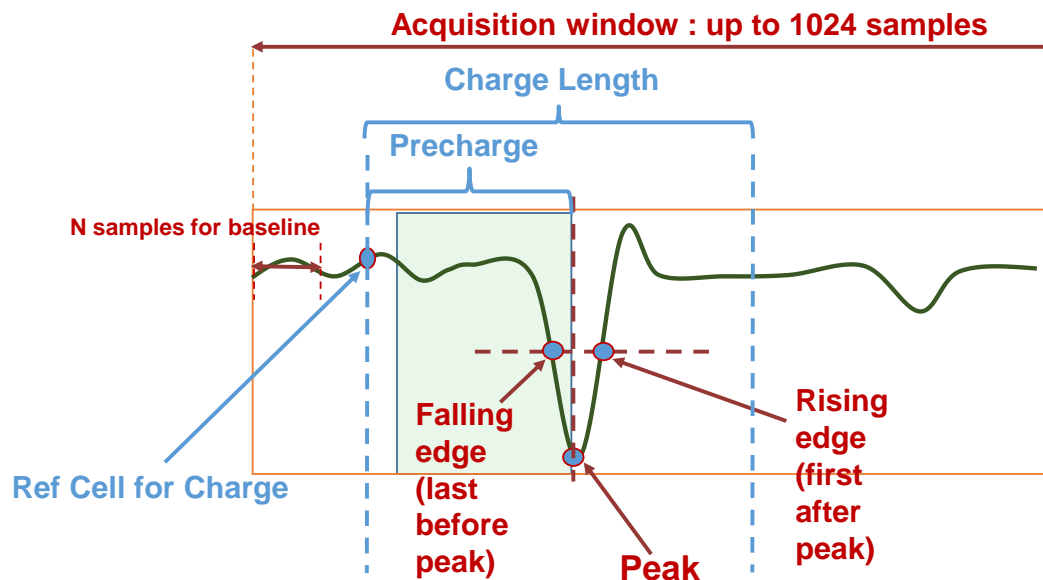
Figure 5.14: *Rate Statistics window*

5.7.3 Measurement Parameters window

- **Measurement Parameters:** by clicking on this item, the user opens an eponym window (see **Figure 5.16**). There, all the parameters needed for the measurement can be defined.

In the FE FPGA, each channel includes a measurement block able to extract information from the signal on the fly (see **Figure 5.15**). This block works with parameters fixed by user. It computes:

- the **Baseline** which corresponds to the mean of the first 16 samples
- the **Peak** amplitude, relative to the baseline
- the **Peak time** (sample corresponding to the peak location)
- the **Charge** contained in the signal (see below for the corresponding parameters)
- the time of the **Rising Edge** (can be the leading or the falling edge depending on pulse polarity)
- the time of the **Falling Edge**.
- the combination of the two edges gives the **Time Over Threshold (TOT)** of the signal.



Programmable options :

- Peak polarity: Pos/Neg
- Forced/Extracted baseline
- CFD/Fixed Threshold
- CFD Ratio (x 1/16)
- Ref cell for Charge / Start from peak (=> precharge)
- Charge Length

Figure 5.15: measurement parameters and results

For the peak amplitude calculation, the user has to define the polarity. The baseline can be that calculated right before, or a fixed value defined by the user in two's complement like the ADC data.

For the charge, there are two possibilities: either the user defines a starting sample (**Ref Cell For Charge**) and a length (**Charge Length**), or the firmware automatically starts from the peak, gets back over a user-defined number of cells (**Precharge**), and then applies **Charge Length**.

For both rising and falling edge times, the threshold can be chosen between two possibilities: either a constant fraction of the peak amplitude (**CFD**), or a **fixed threshold**. Both can be parameterized by user. The constant fraction is coded with steps of 1/16 over 4 bits, thus 0xF corresponds to 15/16 of the peak. The fixed threshold is coded over 12 bits in two's complement.

- **General parameters:**

- **Measurement source:** this box defines if the measurements are performed by firmware or by software. The software option gives slightly better results but the firmware one is much faster. Moreover, the latter permits running with measurements only (see § 5.4).
- **Baseline source:** the baseline value can be computed from the **signal** as the average of the first cells (16 cells for firmware) or **forced** by user. The corresponding forced value then has to be entered in the adjacent box.
- **Display Results on Waveforms:** by clicking on this item, the user can display on the waveforms the location of the peak and of the rising and falling edges times extracted from the signals.

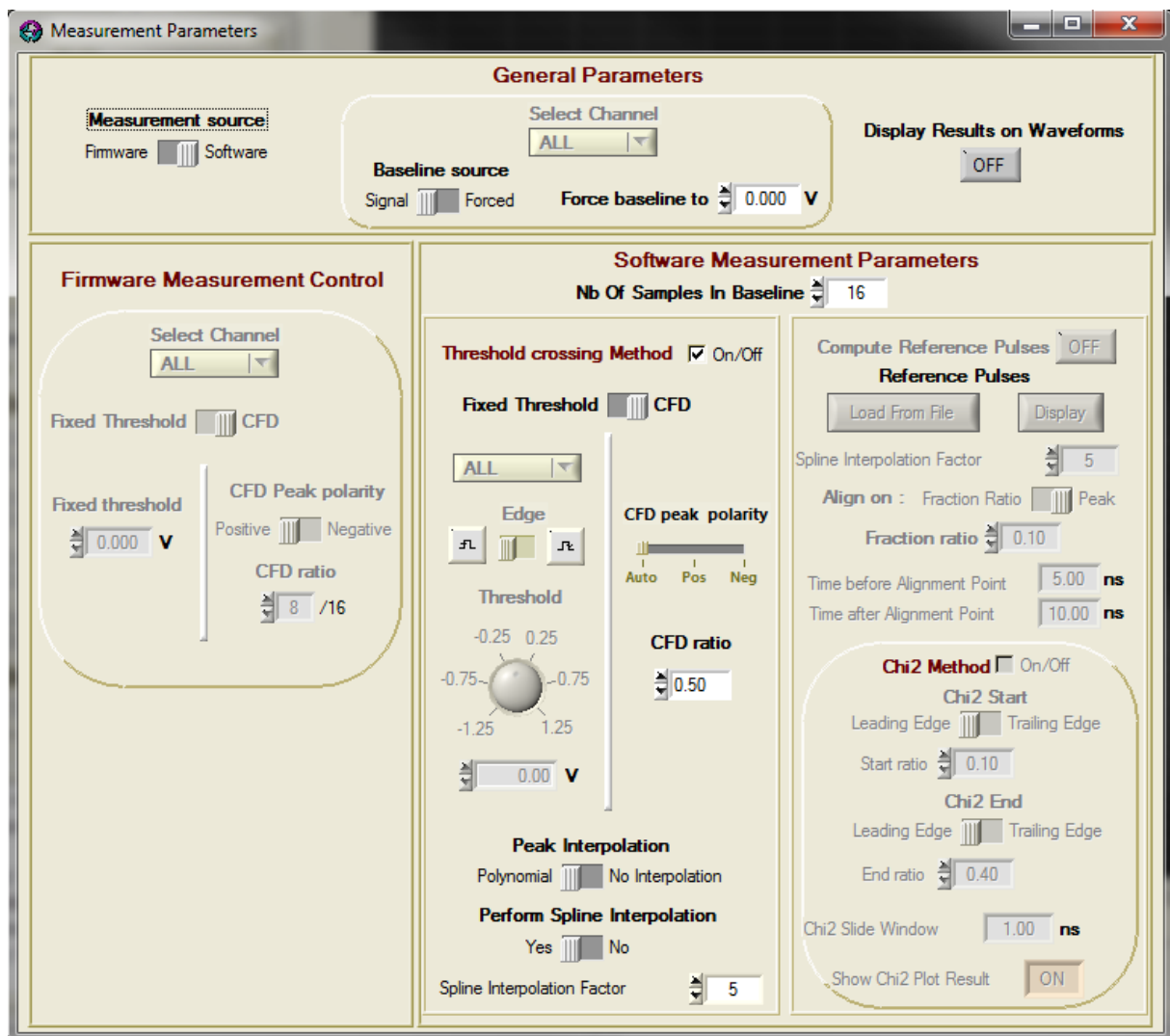


Figure 5.16: Measurement Parameters window

- **Firmware Measurement Control:**
 - **Select Channel:** channels can be selected here by groups of two.
 - **Fixed Threshold/CFD:** this box defines if the level used for threshold crossing is a fixed threshold or the result of a constant fraction discriminator (CFD).
 - **Fixed Threshold:** this is the value of the fixed threshold if this option has been chosen.

- **CFD Peak polarity:** this box defines the polarity of the peak which will be used for the CFD calculation.
- **CFD Ratio:** this box defines the ratio of the peak which will be used for the CFD calculation. Units are in 1/16.
- **Software Measurement Parameters:**
 - **Nb Of Samples In Baseline:** this box permits defining the number of samples used from the first sample of the waveform for the baseline calculation.
 - **Fixed Threshold/CFD:** this box defines if the level used for threshold crossing is a fixed threshold or the result of a constant fraction discriminator (CFD).
 - **Select Channel:** channels can be selected here individually.
 - **Edge:** defines the leading edge for the measurement.
 - **Threshold:** this is the value of the fixed threshold if this option has been chosen.
 - **CFD Peak polarity:** this box defines the polarity of the peak which will be used for the CFD calculation. If set to **Auto**, the choice is made by software depending on the polarity of the highest detected peak.
 - **CFD Ratio:** this box defines the ratio of the peak which will be used for the CFD calculation.
 - **Peak interpolation:** conversely to firmware, the software can perform a polynomial interpolation for defining the peak value more precisely. If **No Interpolation** is chosen, the peak will correspond to the highest (or smallest) sample (as for firmware).
 - **Perform Spline Interpolation:** conversely to firmware, the software can perform a spline interpolation for defining the threshold crossing value more precisely. If **No** is chosen, the peak will correspond to a simple linear interpolation (as for firmware).
 - **Spline Interpolation Factor:** this number corresponds to the number of points added by the spline interpolation between two samples. Default value is 5.

5.7.4 *Baseline Measurements window*

- **Baseline Measurements:** by clicking on this item, the user opens an eponym window (see **Figure 5.17**). In order to perform the measurement, the On/Off checkbox has to be checked.

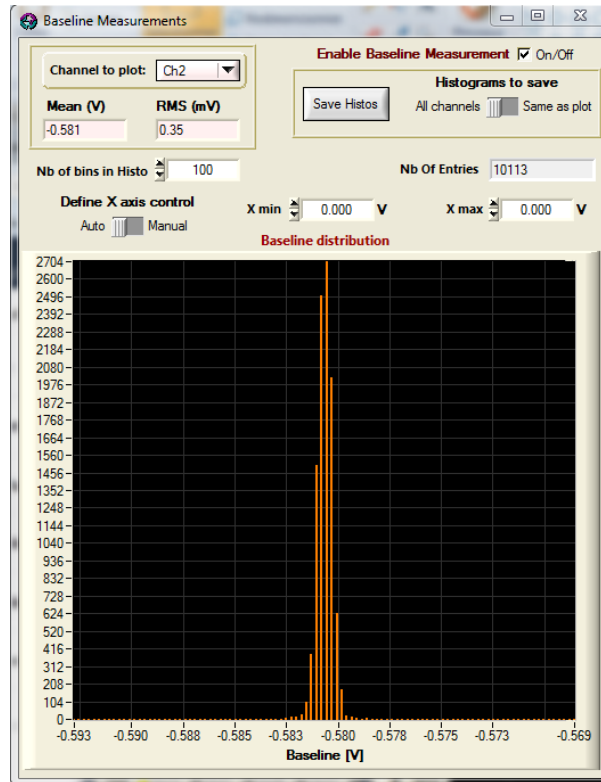


Figure 5.17: Baseline Measurements window

5.7.5 *Amplitude Measurements window*

- **Amplitude Measurements:** by clicking on this item, the user opens an eponym window (see **Figure 5.18**). In order to perform the measurement, the On/Off checkbox has to be checked.

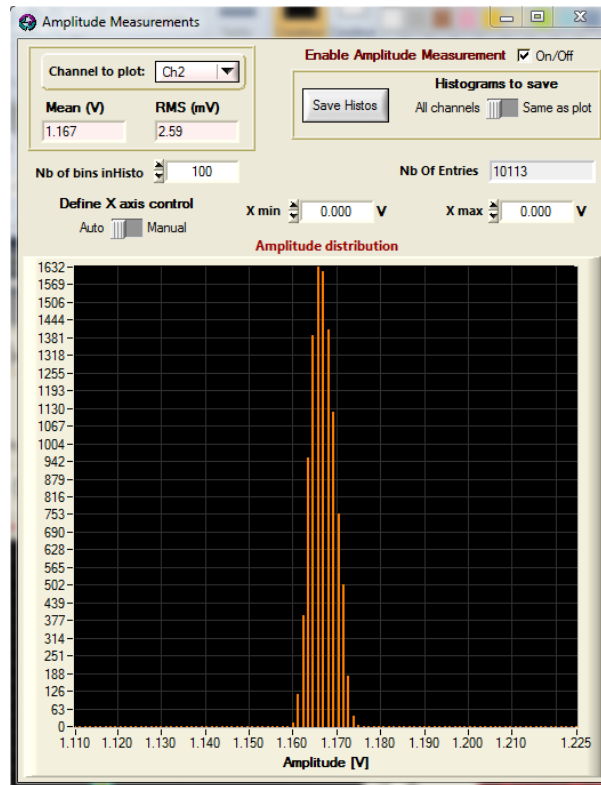


Figure 5.18: *Amplitude Measurements window*

5.7.6 Charge Measurements window

- **Charge Measurements:** by clicking on this item, the user opens an eponym window (see **Figure 5.19**). In order to perform the measurement, the On/Off checkbox has to be checked.

There are two ways for measuring the charge: based on the peak on or a fixed sample position (see **Figure 5.15**).

- **Enable dynamic charge:** when checking this box, the user selects the dynamic charge mode where the charge calculation is based on the peak location. The calculation gets back from the peak over a user-defined number of cells (*Precharge*), and then applies *Charge Length*. If the box is not checked, calculation starts from a fixed sample (*Ref Cell For Charge*) and then applies *Charge Length*.
- **Channel selection** here concerns groups of 2 channels.
- **Start charge at:** defines the start sample (*Ref Cell For Charge*) when the dynamic charge mode is not selected.
- **Before Peak:** defines the distance (*Precharge*) from the peak where the charge calculation has to start when the dynamic charge mode is selected.

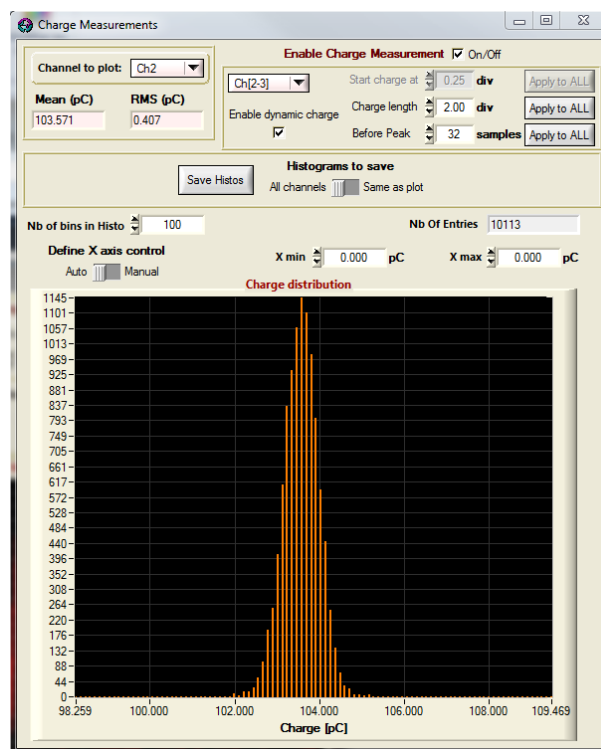


Figure 5.19: Charge Measurements window

5.7.7 *TOT Measurements window*

- **TOT Measurements:** by clicking on this item, the user opens an eponym window (see **Figure 5.20**). In order to perform the measurement, the On/Off checkbox has to be checked.

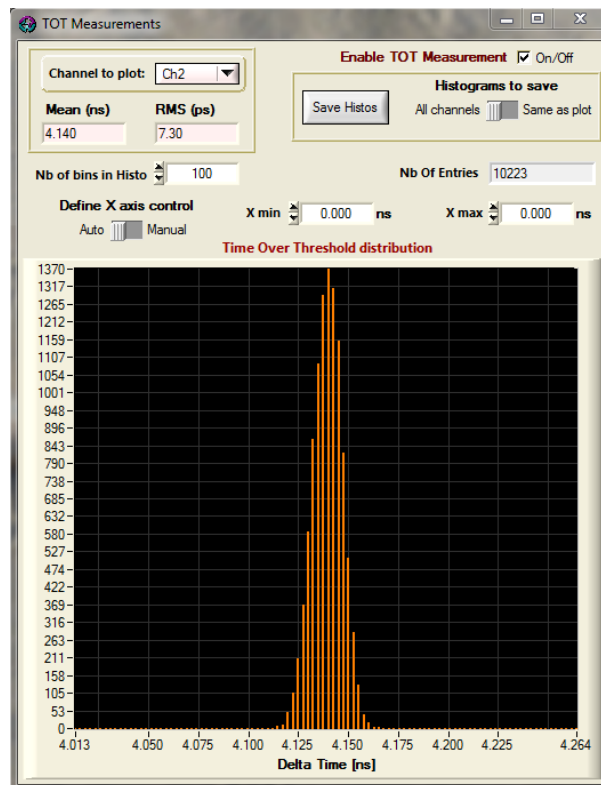


Figure 5.20: *TOT Measurements window*

5.7.8 *Time Measurements Histogram window*

- **Time Measurements Histogram:** by clicking on this item, the user opens an eponym window (see **Figure 5.21**). In order to perform the measurement, the On/Off checkbox has to be checked.

This windows displays both the distribution and the average of the distance measured.

- **Time distance between:** these 2 boxes permit defining the channels used for the time difference histogram.

Warning: always **reselect both channels** once the first time the window is opened in order to be sure of the display.

- **Exclude Pulses with distance:** checking this box permits filtering the displayed events based on the distance between the signals. All the events outside the defined time window won't enter the histograms.
- **Exclude Pulses with Peak Amplitude:** checking this box permits filtering the displayed events based on the amplitude of the signals.
- **Max Peak-Threshold distance:** checking this box permits filtering the displayed events based on the distance between the peak and the threshold crossing time.

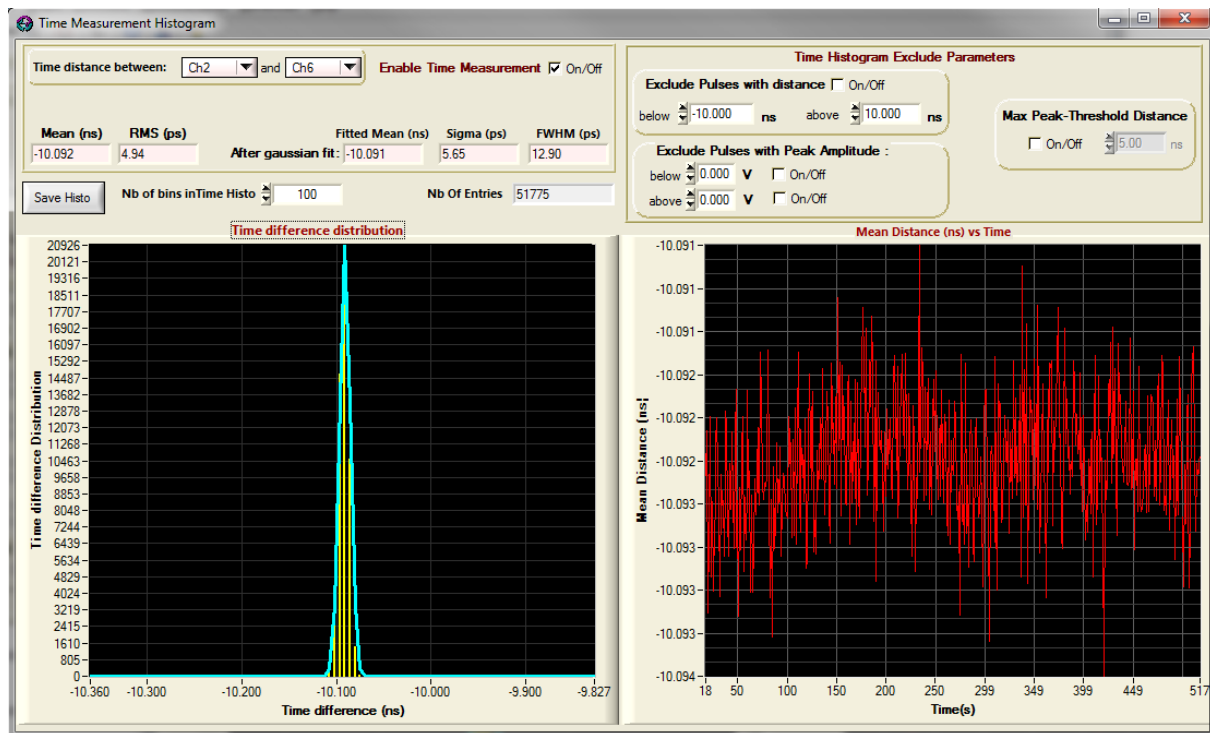


Figure 5.21: *Time Measurements Histogram window*

5.7.9 XY Measurements window

- **XY Measurements:** by clicking on this item, the user opens an eponym window (see **Figure 5.22**). In order to perform the measurement, the On/Off checkbox has to be checked.

The idea here is to plot any measurement on any channel versus any other measurement on any channel ...

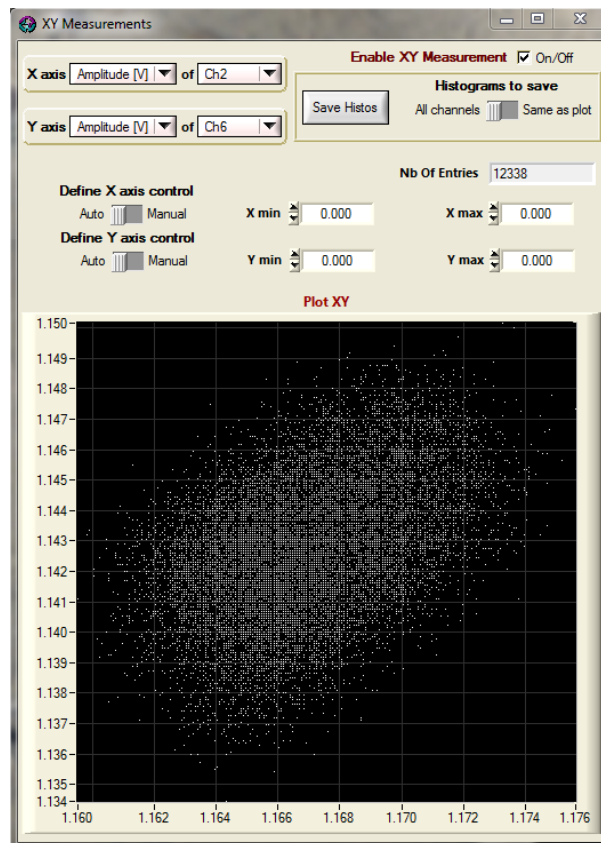


Figure 5.22: XY Measurements window

5.8 Advanced menu

This menu (see **Figure 5.23: Advanced menu**) permits running the channel pulsers and accessing a specific type of run (rate vs amplitude). The rest of the menu has a restricted access for standard users.

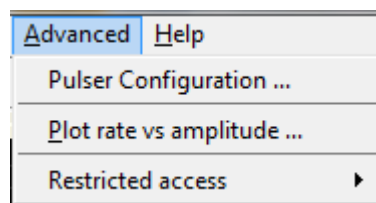


Figure 5.23: *Advanced menu*

- **Pulser Configuration:** by clicking on this item, the user opens an eponym window (see Figure 5.24). In order to perform the pulsing, the On/Off checkbox has to be checked.
 - **Select Channel:** here, the channel selection is individual.
 - **Pattern:** this is a 16-bit word. The 16 bits are sent in sequence, LSB first. Each bit duration corresponds to one main clock period (itself corresponding to 16 samples). Figure 5.25 shows an example of pattern pulsing with a pattern value of 0xC755.

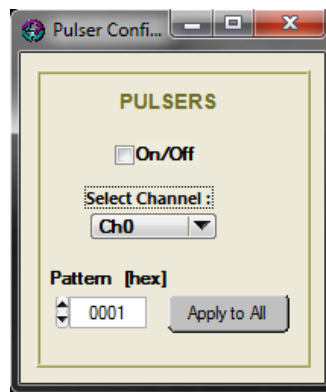


Figure 5.24: *Pulser Configuration window*

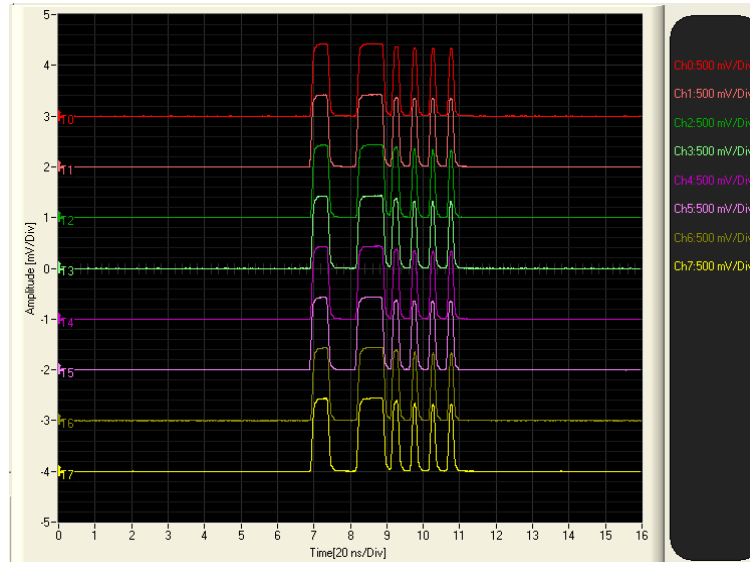


Figure 5.25: *example of pulse pattern*

- **Hit Rate Vs Threshold Plot:** by clicking on this item, the user opens an eponym window (see Figure 5.26). In order to perform the pulsing, the On/Off checkbox has to be checked.

This specific type of run permits plotting the hit rates depending on the threshold voltage applied on the discriminators. It is especially useful for SiPM characterization.

- **Min & Max Thresholds:** those are the start and end value for the run.

- **Nb of steps for plot:** this is the number of equidistant threshold values which will be used for the run.
- **Counting time / step:** this is the time spent for performing the rate measurement on each of the steps.

Figure 5.26 shows an example of use of this plot when no signal is put on the inputs and the thresholds cross the noise.

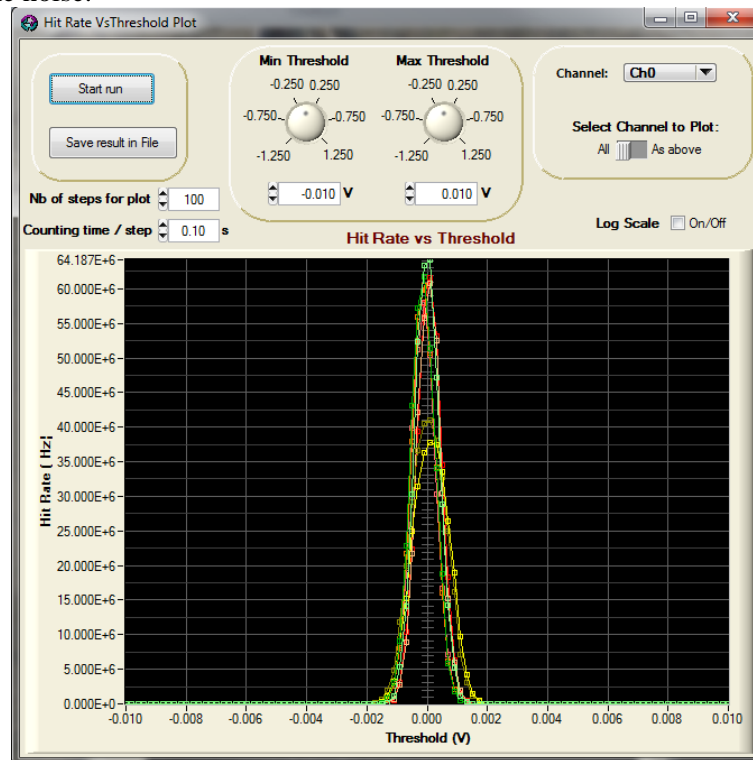


Figure 5.26: *Hit Rate Vs Threshold Plot* window

5.9 Help menu

This menu (see **Figure 5.26**) permits getting help about the hardware and software.

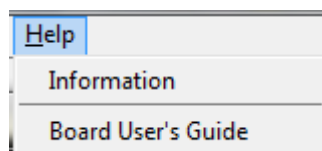


Figure 5.27: *Help* menu

- **Information:** by clicking right on an item, a bullet is supposed to give advices but this feature is not operational yet.
- **System User's Guide and Software User's Guide** give access to detailed documentation.

6 THE ICONS

All the icons correspond to a command located in one of the menu fields.
















Icon	Meaning	Menu	Look at
	Global Reset	Interface	§ 5.1
	Start Run	Run	§ 5.4
	Stop Run	Run	§ 5.4
	Enable Cursors	Graph	§ 5.5
	Disable Cursors	Graph	§ 5.5
	Zoom In	Graph	§ 5.5
	Zoom Out	Graph	§ 5.5
	Board & FPGA versions	Firmware	§ 5.6
	Noise statistics ...	Measurements	§ 5.7
	Rate statistics ...	Measurements	§ 5.7
	Measurement parameters ...	Measurements	§ 5.7
	Pulser Configuration ...	Advanced	§ 5.8
	Information	Help	§ 5.9
	System User's Guide	Help	§ 5.9
	Software User's Guide	Help	§ 5.9

Table 6.1: icon list

7 THE TABS

7.1 Main tab

This tab defines the main parameters of the run (see **Figure 7.1**).

- **DISPLAY group:**
 - **Partial or All events:** by default, all events are displayed. **But this limits the event rate.** Selecting **Partial** then permits displaying only one out of N events, thus increasing drastically the event rate.
 - **Partial: every ...:** this box defines **one out of how many** events is displayed.
 - **Average:** checking this box enables the averaging of the waveforms. **Warning:** this is possible only if the **Plot Alignment** option has been switched ON (see § 5.5).
 - **Persist:** checking this box enables the persistence of the waveforms until the start of a new run.
 - **FFT:** checking this box enables the display of the FFT of the signals.
 - **Normalize:** unused.

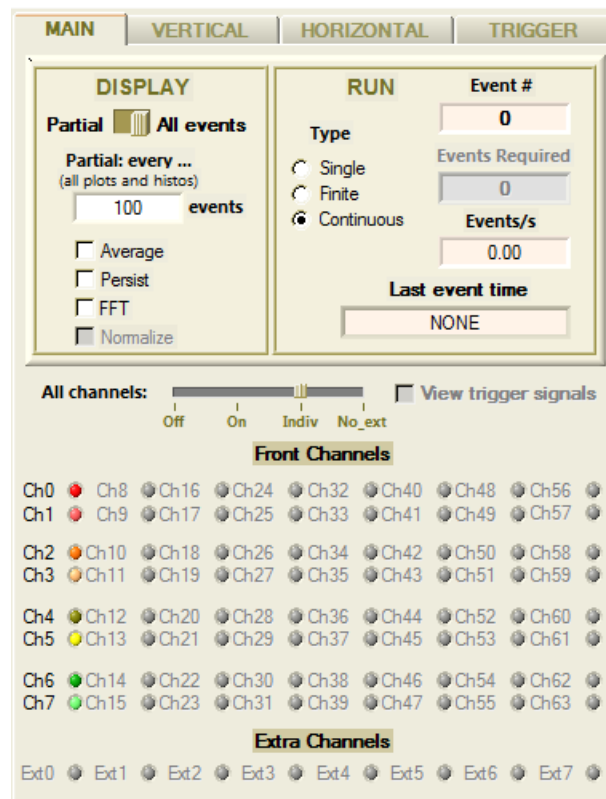


Figure 7.1: Main tab

- **RUN group:**
 - **Type:** by default, runs are launched in continuous mode. **This does not permit saving data to files** and the item **Save Run to File** in the **Run** menu is dimmed. If user wants to save data or to perform a finite run, select the **Finite** option and enter the number of required events.

7.2 Vertical tab

This tab defines the main “vertical” parameters (see **Figure 7.2**).

- **POSITION group:**
 - **All plots:** this selection tree permits defining easily vertical display rules which will be applied to all channels. By default, events are displayed by groups of 2. Choosing the **User defined** option permits selecting the position on an individual channel basis.
- **OFFSET:** this voltage is a real offset added to the signal at the input of the boards. It is connected to 16-bit DACs permitting adding up to a ± 1.25 V DC offset in order to optimize the dynamic range of the input signal.
- **POSITION:** the position is purely linked to display and has no effect on the hardware.
- **SCALE:** the scale is purely linked to display and has no effect on the hardware. The scale value of all channels is continuously displayed (in mV) on the right of the waveform window.

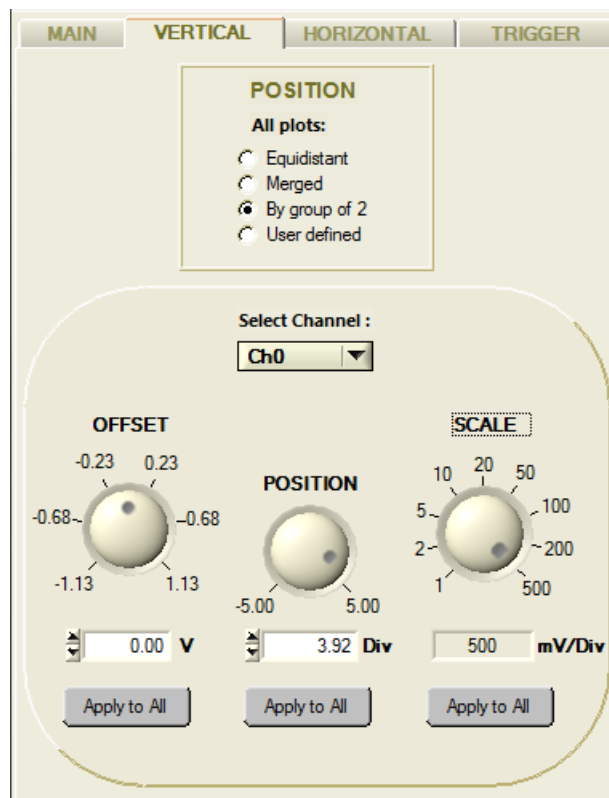


Figure 7.2: Vertical tab

7.3 Horizontal tab

This tab defines the main “horizontal” parameters (see **Figure 7.3**).

- **TRIGGER DELAY:** this parameter permits fixing the position of the trigger in the waveform window. Increasing the value will move the waveform to the left. There is no way to move it to the right since the position with a trigger delay of zero corresponds to the shortest possible time between the trigger and the end of the event recording in the analog memory. This parameter applies to groups of 2 channels.
- **SAMPLING:** this parameter permits fixing the frequency used for sampling the signal. Due to the architecture of the PLL chip used for generating the main clock, 8 frequencies are available.
- **Recording depth:** by default, the recording depth is of 1024 samples. It can be reduced by steps of 16, down to 64 samples. This can permit reducing the dataflow and increasing the event rate.
- **Set clock source:** this switch permits selecting between the internal clock delivered by the system PLL and an external clock which will directly be used by the system (bypassing the PLL).
- **Readout Latency:** the so-called **Normal** readout latency corresponds to a frequency of 10 MHz for the analog to digital conversion of the signals stored in the analog memories. In order to reduce the dead-time due to this conversion (125 μ s for a full 1024-sample event), the frequency can be doubled (20 MHz) when the **Short** readout latency option is selected. The only small drawback in this case is a small increase of the signal noise (10%).

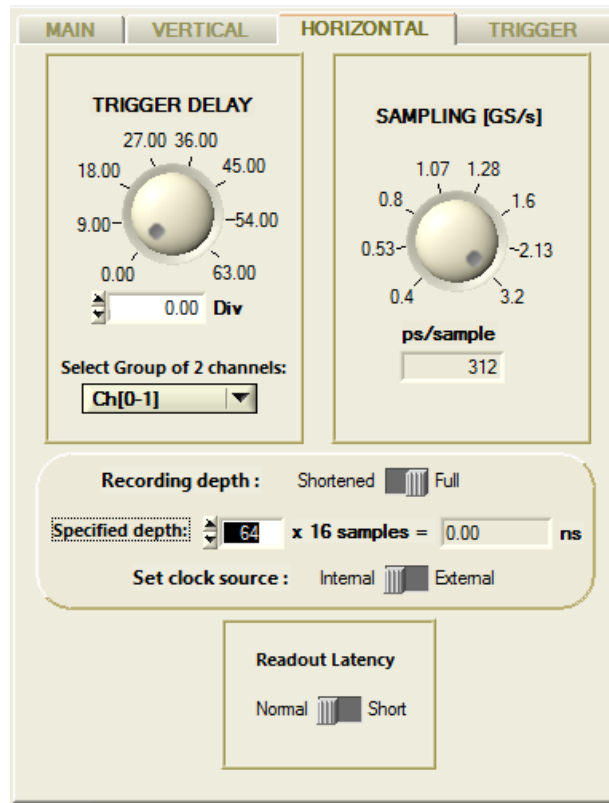


Figure 7.3: Horizontal tab

7.4 Trigger tab

This tab defines the main trigger parameters (see **Figure 7.3**).

- **Trigger Sources:** all channels can be selected individually for participating in the trigger decision. **Note that this selection is independent of the fact that the channel is selected or not for readout.**
- **Trigger Type:**
 - **Software:** sent by software
 - **Normal:** based on the OR of the channel discriminators with respect to the defined thresholds
 - **Internal:** sent by an internal asynchronous oscillator source running at ??? kHz.
 - **External:** received from the Trigin input.
 - **Coincidence:** all selected channels participate to the coincidence via the defined gate length. The gate is started individually before the channel enters the coincidence.
 - **Majority:** this is a specific coincidence mode where if, among the selected channels, the number of channels present simultaneously is higher than the defined value, the trigger will occur.
 - **Channels are paired:** this is a specific variant to the Normal mode where channels are paired (0 & 1, 2 & 3, ...) in coincidence before entering the global OR. This permits among others optimizing the trigger for strip detectors.
- **Gate Length:** this is the length of the gate generated in each channel when the discriminator crosses the threshold. It varies with the sampling frequency.

- **THRESHOLD:** this is the threshold voltage applied to the discriminator of the selected channel.
- **Edge:** this is the edge of the signal from the discriminator of the selected channel used for the trigger decision.

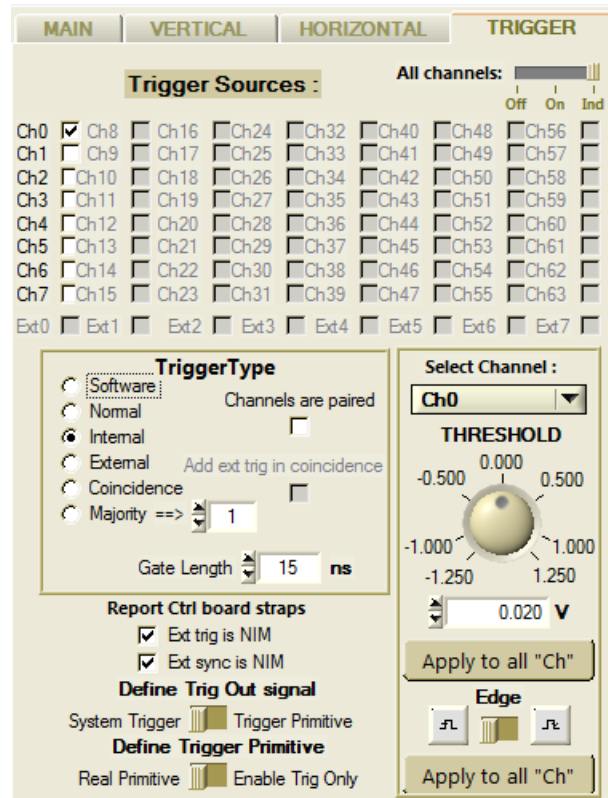


Figure 7.4: Trigger tab

- **Report Ctrl board straps:** on the first version of the controller board used in the 64-channel crate, there are straps located on the board. The checkboxes **Ext trig is NIM** and **Ext sync is NIM** permit reporting the strap options chosen by user to the software. If badly reported, this may block the hardware interface.
- **Define Trig Out signal:** **Trig Out** signal is output on the system front panel. By default, it is the **System Trigger**. But if one wants to perform an external trigger based on information from this system, the **Trigger Primitive** option has to be selected.
- **Define Trigger Primitive:** this option permits defining the Trigger Primitive as a real contribution to the trigger (**Real Primitive**) or as a “non-busy” information (**Enable Trig Only**). Indeed, the WaveCatcher systems cannot accept triggers if they are “busy” (during the conversion dead-time or if the event buffers are full).

8 WAVEFORM DISPLAY

The waveform display permits displaying all the enabled channels. The vertical scale is shown permanently on the right (in mV/div).

The bidirectional cursors permit performing horizontal and vertical measurements which are displayed below the graph (in ns for X and divisions for Y). The same cursors permit zooming inside the zone they define thanks to the **Zoom In** command.

The vertical position of the waveforms can be changed thanks to the **Position** knob in the **Vertical** tab.

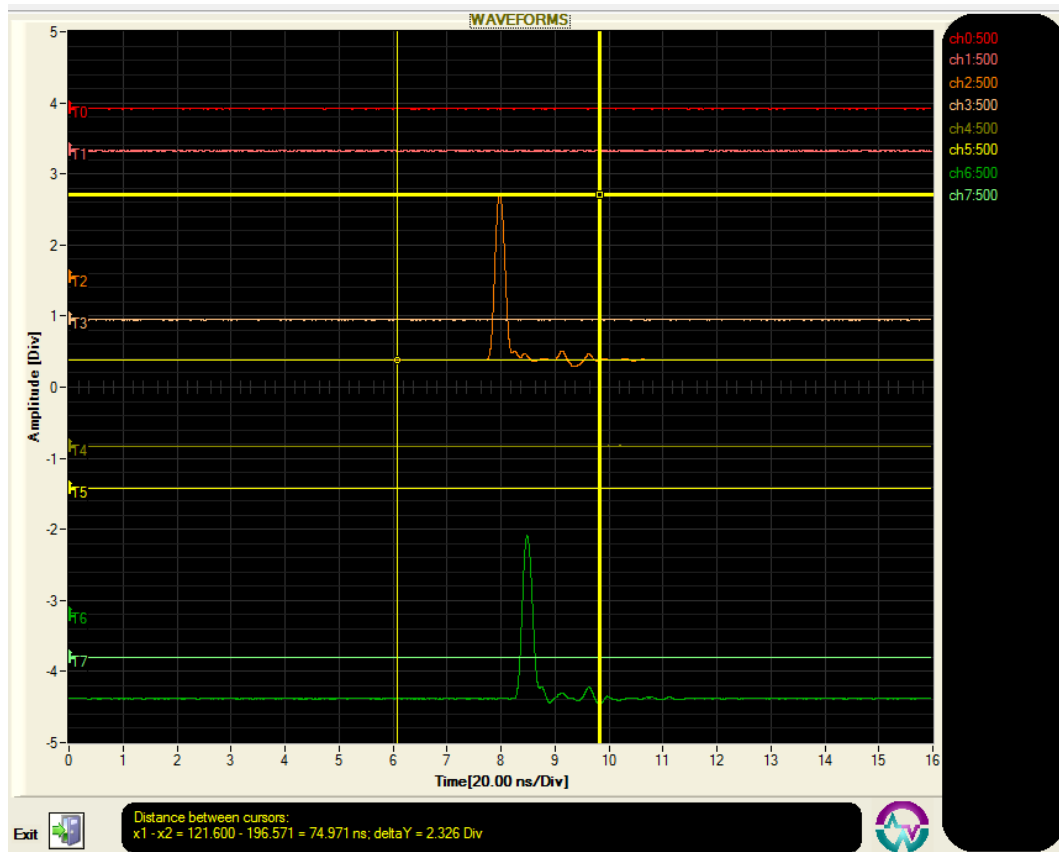


Figure 8.1: Waveform graph

9 MESSAGE WINDOW

This window comprises 3 different tabs, associated to *Infos*, *Warnings* and *Errors*. The *Infos* tab contains all messages, whereas the other filter them depending on their severity.

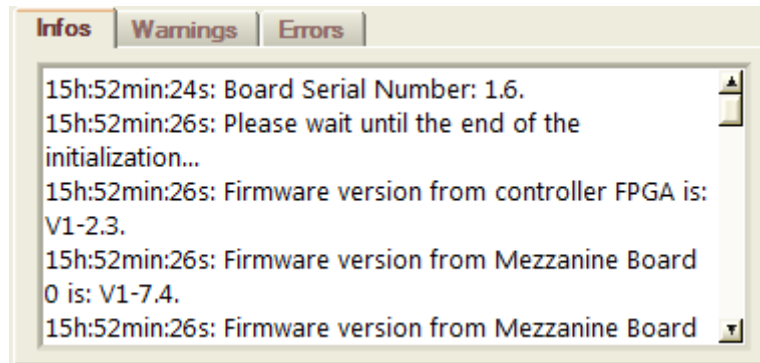


Figure 9.1: Message window