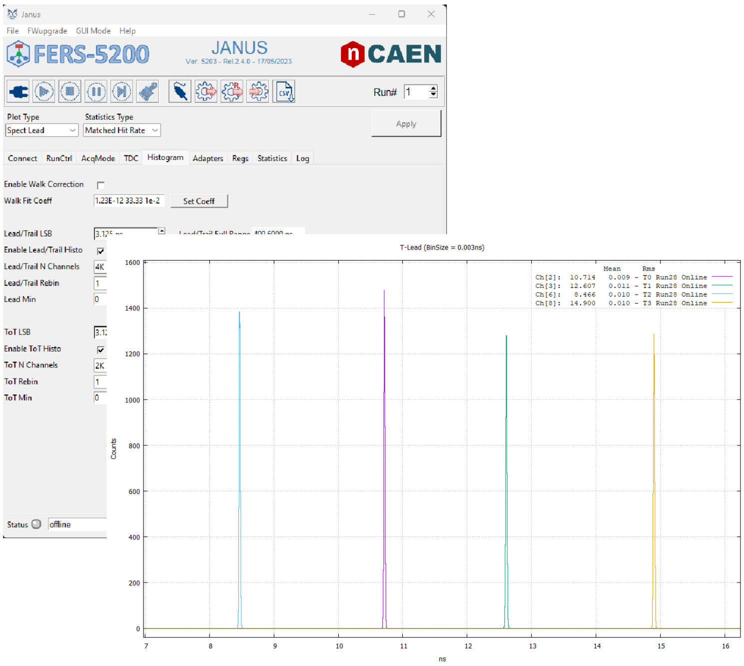
Rev. 0 - February 7th, 2024

Janus 5203

CAEN A5203(B)/DT5203 Readout Software



CAEN Tools for Discovery

User Manual
UM9636

Purpose of this Manual

The User Manual contains the description of the Janus readout software for FERS-5200, the description of its architecture and parameters, and instructions for its installation.

Change Document Record

Date	Revision	Changes
Feb 7th, 2024	00	Initial Release

Symbols, Abbreviated Terms and Notation

ADC	Analog-to-Digital Converter
ASIC	Application Specific Integrated Circuit
DAQ	Data Acquisition
DCR	Dark Count Rate
FERS	Front-End Readout System
FERS-CB	FERS Collector Board
FPGA	Field Programmable Gate Array
FSR	Full Scale Range
GUI	Graphical User Interface
IDLE	Integrated Development and Learning Environment (Python)
LSB	Least Significant Bit
LVTTL	Low Voltage TTL
MUX	Multiplexer
OS	Operating System
PC	Personal Computer
PCB	Printed Circuit Board
RMS	Root-Mean-Square
SiPM	Silicon Photo-Multiplier
ToA	Time of Arrival
TD	Time Discriminator
ToT	Time over Threshold
USB	Universal Serial Bus

Reference Documents

[RD1] UM9085 – A5203(B)/DT5203 User Manual

[RD2] PicoTDC Datasheet. Available at `https://kt.cern/technologies/picotdc`

[RD3] UM8977 – DT5215 User Manual

[RD4] Picosecond Time to Digital Converter, Manual V. 0.91, May 2021

[RD5] DS9756– A52xx Accessories for A5203 FERS-5200 Units Datasheet

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.

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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

1.1 FERS-5200 System

Janus 5203 is an open source software for the control and readout of A5203(B)/DT5203 FERS units **[RD1]**.

A5203/DT5203 FERS units use the picoTDC chip (produced by CERN **[RD2]**) for high-resolution multi-hit time measurements on 64 channels. The A5203B version houses an additional mezzanine card with a second picoTDC chip, thus implementing a 128 channel TDC module.
Each readout channel accepts LVDS signals[1] and measures the time stamp of both rising and falling edges with an LSB of 3.125 ps. In this way, the unit is able to reconstruct the Time of Arrival (ToA) of signals as an absolute timestamp or as a ΔT with respect to a common Tref pulse. The picoTDC can also acquire the Time over Threshold (ToT) information and combine it with the edge time stamp.

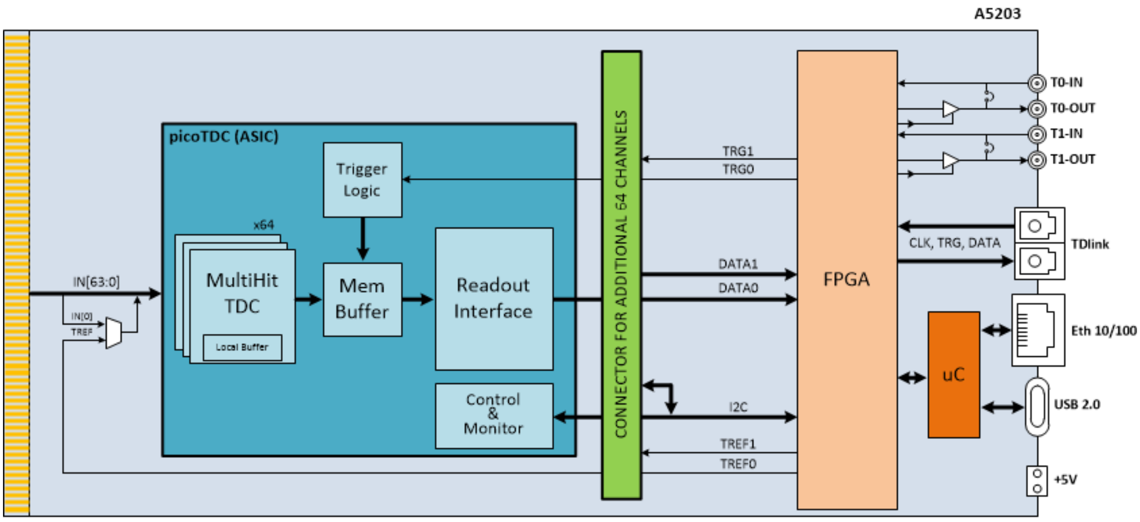


Fig. 1.1: Simplified block diagram of the A5203/DT5203 FERS-5200 unit.

For small setups a single A5203(B)/DT5203 unit can be used stand alone, without any additional hardware, by simply connecting the unit to a PC via USB 2.0 or Ethernet 10/100BASE-T. For large readout systems, a flexible and scalable network of units can be created by means of the high speed optical link called TDlink[2]. The TDlink system supports up to 128 FERS units to be connected to and managed by one DT5215 FERS Data Concentrator Module. The TDlink supports optical daisy chaining and provides slow control, high speed data readout, synchronization of the units (clock and sync distribution), as well as command broadcasting for time resets, run start/stop, etc.

Janus 5203 can manage up to 16 A5203(B)/DT5203 boards connected via Ethernet or USB. In case of connection via the DT5215 FERS-5200 data Concentrator Board (TDlink connection), Janus 5203 can manage up to 128 FERS-5200 units.
The software permits the configuration of the hardware parameters, reported in the Janus 5203 configu-

[1] Max common mode = 1.2 V Max absolute voltage = 1.45 V
[2] TDlink is a CAEN proprietary protocol for communication and synchronization via optical link.

ration file, and the management of the data acquisition (runs/jobs) and readout.
The data acquisition can be performed in:

- **Common Start**
- **Common Stop**
- **Trigger Matching**
- **Streaming**

Acquisition Mode, and in:

- **LEAD_ONLY**
- **LEAD_TRAIL**
- **LEAD_TOT8**
- **LEAD_TOT11**

Measurement Mode. See **[RD1]** for more details.

During the acquisition, Janus 5203 performs the system monitoring (boards temperatures, dead time, etc.), and can plot spectra and graphs of the acquired hits. Moreover, Janus 5203 prints on screen (via console or GUI) some statistics of the run (counts, events lost, trigger rate, data throughput, etc.).
The readout data can be saved to disk in list files and spectra (ToA, ToT), together with a file reporting the info of the acquired data run. A further Sync List file can be saved in case of synchronization of more A5203(B)/DT5203 units.
Janus 5203 manages also the A5203(B)/DT5203 FPGA Firmware upgrade.

1.2 Janus 5203 Architecture

Janus 5203 is an open-source software composed of two parts, one written in C, which is the real heart of the application, one written in Python which manages only the user interface and communicates with the C program via socket. The plots are executed through an external tool (*gnuplot*). All the configuration parameters, both of the board and of the software, are written on a textual configuration file.

It is possible to launch and use Janus 5203 in two different modes:

- **Console Mode**. In this case, the Python part of the software is not used. The user can edit the configuration file with any text editor and save the proper values for the desired parameters. Then, the user can launch ”JanusC.exe”, which starts in a purely textual console window. The application writes a series of messages (which are also saved in a log file) and, during the run, prints statistics on the screen. Commands are given via predefined keys (see Chap. **4**). The only graphical part is the plot, which is managed by gnuplot.

  In **Fig. 1.2** the software block diagram when working in Console Mode is shown.

  JanusC is open-source and can be used as a platform for the development of custom DAQ, tailored to the specific application. Indeed, the user can change the data treatment, the acquired statistics and the output file format.
- **GUI Mode**: In this case, the user only has to run the Python program ”JanusPy.pyw”, which calls the C program ”JanusC.exe” and connects to it via a socket to send commands and receive messages which are then displayed in the Python GUI (see **Fig. 1.3**).

Note: When operating in GUI Mode, the user can decide to connect or not via socket to the ”JanusC.exe” file. In case the socket connection is not established, the GUI can be used to modify the configuration file, i.e. it is simply used as a configuration panel.

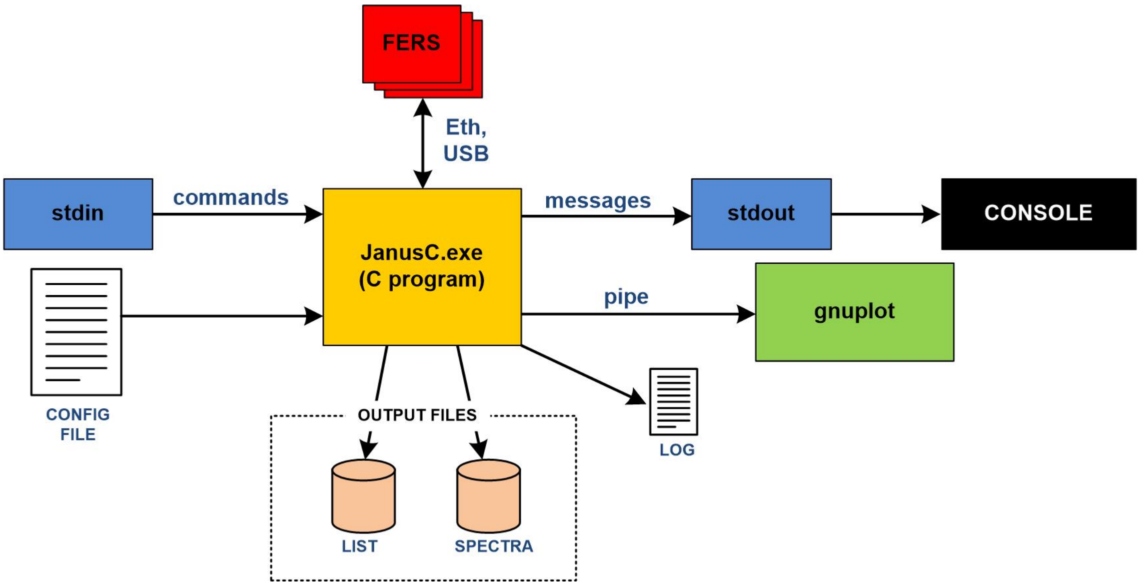


Fig. 1.2: Console Mode block diagram.

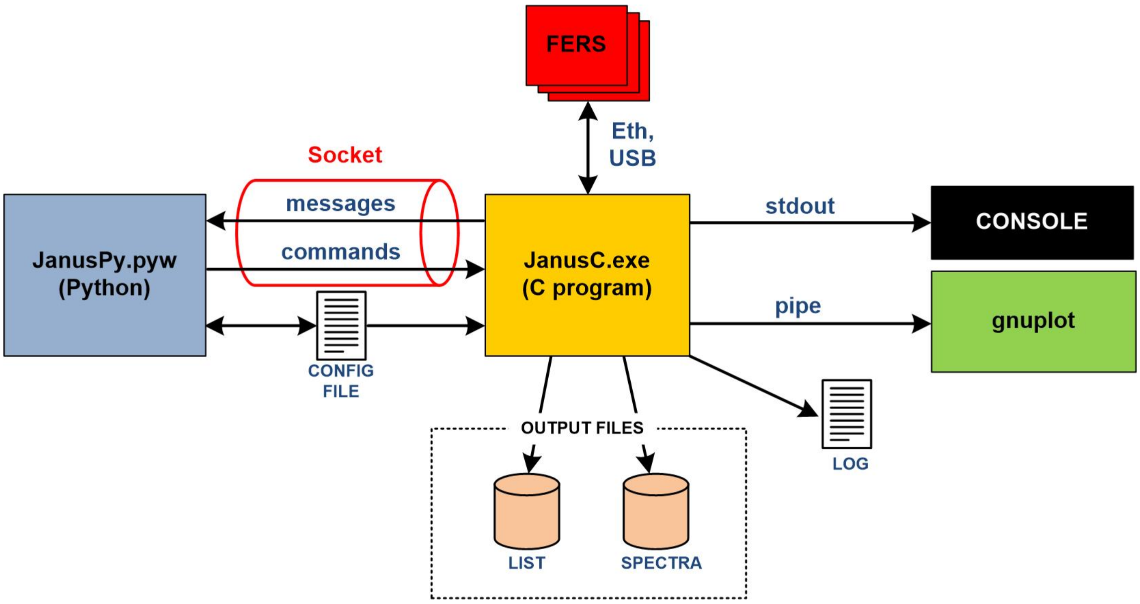


Fig. 1.3: GUI Mode block diagram.

2 Installation

The A5203(B)/DT5203 is fully supported by the Janus 5203 software for Windows® and Linux®.

Janus 5203 runs on Windows OS, 10 or higher, and Linux OS, both 64-bit. Since the source codes are available, it is in principle possible to compile them in a 32-bit platform, prior the installation of the correct drivers, in case of USB connection.

Janus 5203 can run in ”GUI” or ”console” mode. For the GUI mode, Janus 5203 requires the third-party software Python release 3.8.1 or later, downloadable from the python website, while for the console mode it is sufficient to run the program ”JanusC”.

Before installing the software, please make sure that:

- The A5203(B)/DT5203 hardware is properly installed (refer to the A5203(B)/DT5203 User Manual **[RD1]** for hardware installation instructions).
- A cable connection is established between the host PC and the target board (either USB or Ethernet).
- The required USB driver (Windows only) is correctly installed in case of a USB connection to the board (refer to the A5203(B)/DT5203 User Manual **[RD1]** for USB driver installation instructions).

As a summary, in order to use Janus 5203 the user needs:

- Windows 10 (or higher) / Linux OS (64-bit).
- Python interpreter, e.g. IDLE 3.8.1. (not necessary in Console Mode).

2.1 Windows Installation

Janus 5203 does not have an installer. It is provided by CAEN as a compressed ”.zip” file to be unpacked in a directory on the PC that the user has write access to. The user should follow the instructions below in order to properly run the software:

1. Download the installation package from CAEN website for Windows OS (login required).
2. Extract the files.
3. Open the ”Janus_5203_x.y.z” folder (with x, y, z being the numbers indicating the software release).

The ”Janus” folder contains the C and Python sources, the Microsoft Visual Studio project (Community Edition 2019) in case the user may want to modify and recompile the software, gnuplot, and a folder with the executables.

Here follows the list of folders contained in the software package:

- **bin**: folder containing executables, python scripts, configuration files, other service files needed by Janus 5203.
- **bin/DataFiles**: default folder for saving the output files of the acquisitions.
- **build**: folder containing the Microsoft Visual Studio project.
- **FERS_USB_driver**: folder containing the USB driver (Windows).
- **gnuplot**: folder containing the installation of gnuplot.
- **img**: folder containing icons for the GUI.
- **macros**: folder containing useful macros that can be loaded into Janus 5203.
- **src**: folder containing the software C-source and header files.

2.2 Linux Installation

Janus 5203 for Linux is provided by CAEN as a compressed ".tar.gz" file to be unpacked in a directory on the PC that the user has write access to. The user should follow the instructions below in order to properly run the software:

1. Download the Janus 5203 software from CAEN website for Linux OS (login required).
2. Extract the files in a folder with read/write permissions and enter the "Janus" folder.
3. Run
   `sudo sh Janus_Install.sh`
4. The script will search for missing packages. If any is found, please, install it and run again the Janus_Install.sh file.
5. Once completed, go into the folder "bin" and run
   `python3 JanusPy.pyw` for GUI mode or
   `./JanusC` for console mode

The folder structure is the same as described in Sec. **2.1**

3 GUI Mode

The Janus 5203 software features a Python GUI (”JanusPy.pyw”) which is well suited to start getting familiar with the functionalities of the software itself. As explained in Sec. **1.2**, in this case the user only has to run the GUI, which calls the ”JanusC.exe” application, and connects to it via a socket. The C program, when called by Python, no longer uses stdin and stdout for input and output, instead it uses the socket from which it receives commands and to which it sends messages, which are then displayed in the Janus 5203 GUI.

Note: The screenshots reported in this chapter may change between different versions of the software.

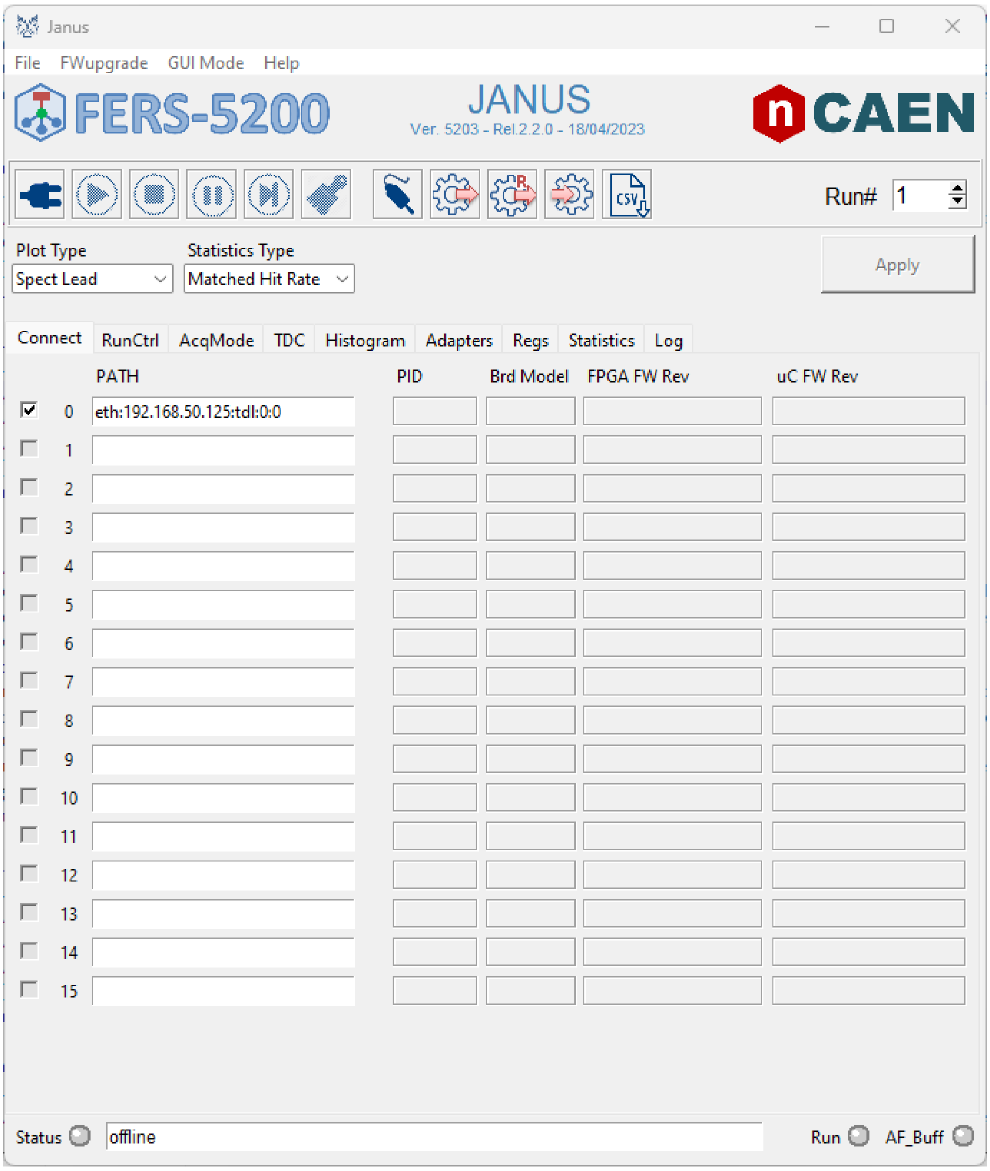


Fig. 3.1: Starting window of the Janus 5203 software GUI.

When the ”JanusPy.pyw” application is launched, an initial screen similar to that in **Fig. 3.1** is opened.
In the Connect Tab, the user has to define in the ”PATH” field the type of connection for the A5203(B)/DT5203 board and then press the ”Apply” button in order to make the changes effective (see Sec. **3.5**).

Note: In the current version of the GUI, the user can connect more than one board (up to 16) via Ethernet by using, for instance, an Ethernet switch, via USB by using, for instance, an USB hub, or via the TDlink connection to the DT5215 Concentrator Board.

Note: Every time the value of a parameter in the Janus 5203 GUI is changed, the user has to press the ”Apply” button to make it effective. By pressing the ”Apply” button the Janus_Config.txt configuration file read by the ”JanusC.exe” application is overwritten.

In the following sections all the parameters and commands of the Janus 5203 GUI are described in detail.

3.1 Menu Bar Items

The Menu Bar (see **Fig. 3.2**) in the top left part of the Janus 5203 GUI hosts the following items: ”File”, ”FWupgrade”, ”GUI Mode” and ”Help”.

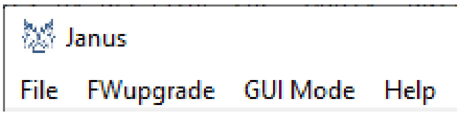


Fig. 3.2: Menu bar of the Janus 5203 GUI.

File

The **File** pull-down menu shows the following items: ”Load Config File”, ”Save Config File”, ”Save Config File As”, ”Load Macro” and ”Quit”.

- *Load Config File*: The command allows the user to open an existing configuration file. A window will be opened in which the user can select the file to be load.
- *Save Config File As*: The set of values currently used for the parameters are saved to a configuration file whose name can be defined by the user, as well as the destination folder. The configuration file can then be loaded via the ”Load Config File” command.
- *Load Macro*: Additional settings can be loaded by means of a .txt file and appended in the configuration of FERS (see **Fig. 3.3**). See for example, in the ”macros” folder, the file ”leds_off.txt”. To select a macro, click on ”Add Macro” button and select the specific file. Once ready, press the ”DONE” button to upload the macro. Finally, click on ”Remove Macro” and ”Remove All Macros” to remove one selected macro or all macros, respectively.
- *Quit*: The command allows the user to quit the Janus 5203 software.

Firmware Upgrade

The **FWupgrade** pull-down menu shows the following items:

- *Upgrade FPGA*: The command opens a window (see **Fig. 3.4**) that allows the user to browse the firmware file to upgrade the FPGA and to visualize the progress of the upgrade. Compliant firmware has .ffu extension.
- *Restore IP 192.168.50.3*: The command restores the default IP address in case the user has modified it previously through the web interface.

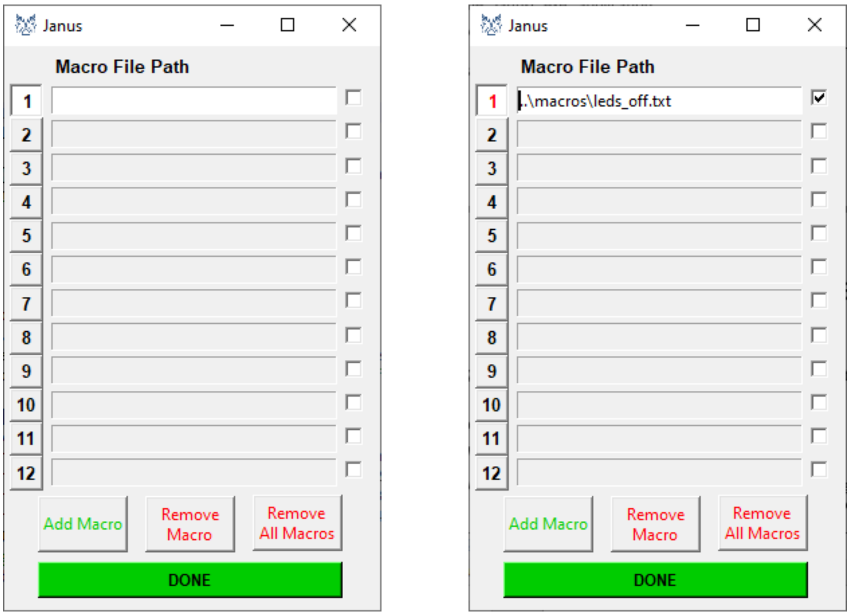


Fig. 3.3: ”Load Macro” window.

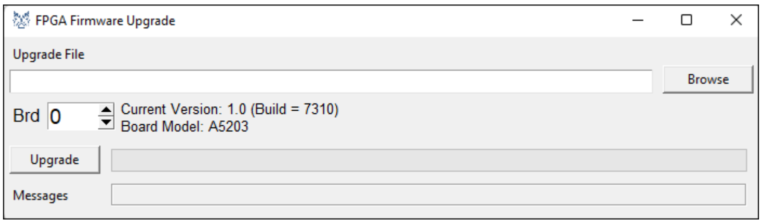


Fig. 3.4: FPGA firmware upgrade window.

Note: Connect via USB to the board to restore the Ethernet IP address.

GUI Mode Command

The **GUI Mode** pull-down menu allows the user to define which parameters are visualized in the Janus 5203 GUI:

- *Basic*: This option allows the user to remove from the GUI the list of parameters more suitable for an advanced use of the software. When working in Basic mode, the parameters which are removed from the GUI window are set to the values defined before switching to this operative mode.
- *Advanced*: This option allows the user to visualize all Janus 5203 parameters in the GUI.
- *Show warning pop-up*: This option enables/disables warning pop-up.
- *Verbose socket messages*: The selection of this option activates report messages received by the socket to be printed in the Log Tab, and enables a deeper level of C log file. Mostly used for debug purposes.

Help

The **Help** pull-down menu shows the following item:

- *About*: The command allows the user to access the software release number and the date of the release.

3.2 Icon Bar

An Icon Bar is present under the Menu Bar, where the different buttons are enabled/disabled depending on the process in progress (see **Fig. 3.5**).

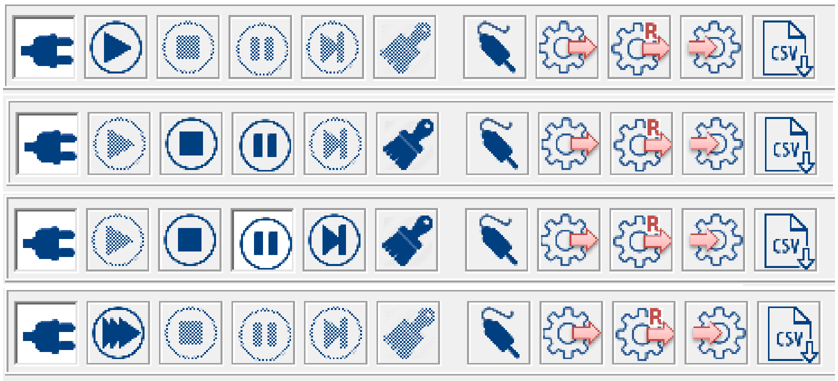


Fig. 3.5: Janus 5203 Icon Bar.

From the top to the bottom, the configurations presented in **Fig. 3.5** are:

- The Janus 5203 GUI is connected to the JanusC.exe application and the boards are connected.
- An acquisition is ongoing.
- The histograms update is paused.
- The jobs (multiple runs) are enabled.

The above icons correspond to the functions described below.

Connect Button

The Connect command  allows the user to enable/disable the socket connection of the Janus 5203 GUI with the "JanusC.exe" application.

Start Button

The Start command  allows the user to start an acquisition.

Start Job Button

The Start Job command  is only available when the **Enable Jobs** parameter is enabled. The command allows the user to start a job, i.e. several consecutive runs (see Sec. **3.15**).

Stop Button

The Stop command  allows the user to stop the acquisition.

Pause Button

The Pause command  allows the user to freeze the histograms update while the data acquisition continues.

Reset Button

The Reset command allows the user to restart an acquisition run and to reset the histograms.

Plot Traces Button

The Plot Traces command allows the user to access the Plot Traces window (see **Fig. 3.6**) to manage the traces to be visualized in the gnuplot window. A maximum of 8 traces from different channels can be visualized at the same time.

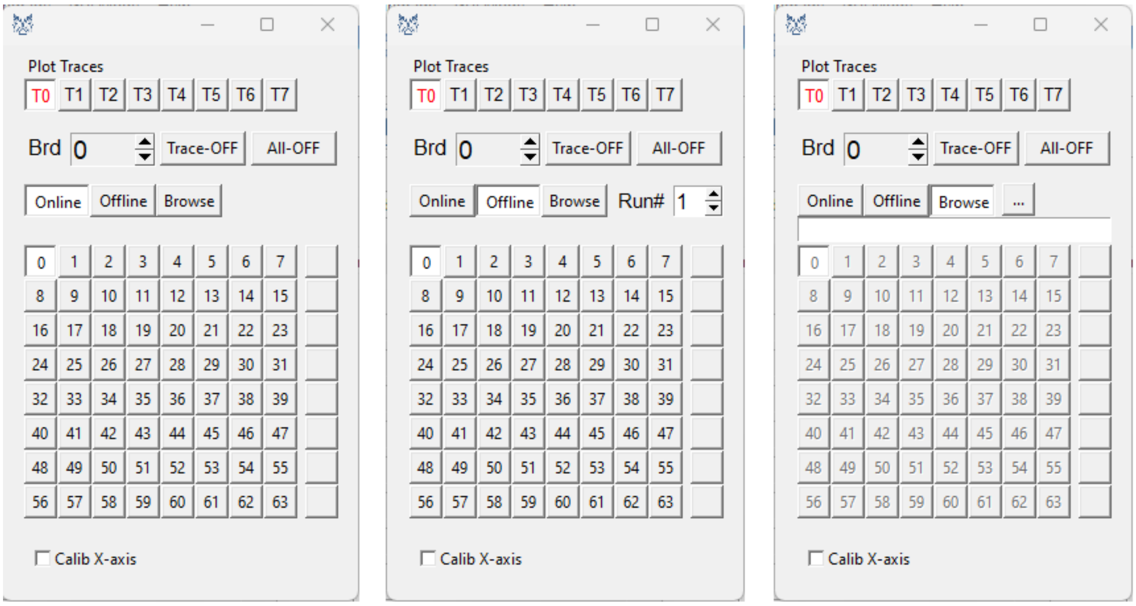


Fig. 3.6: Plot Traces window in default mode (on the left), with the Offline button enabled (in the middle) and with the Browse button enabled (on the right).

The commands present in the window are:

- *TN*: With *N* being a number between 0 and 7. By pressing the button, one of the available 8 traces is selected.
- *Brd*: The arrows next to the box allow the user to choose a trace from one of the connected boards. The trace number can also be written directly into the box.
- *Trace-OFF*: The command disables the visualization in the gnuplot window of the selected trace.
- *All-OFF*: The command allows the user to disable the visualization of all traces.
- *Online*: The command has to be enabled when the user is performing an acquisition and wants to visualize in the gnuplot window data from the ongoing acquisition for the selected trace.
- *Offline*: The command has to be enabled when the user wants to visualize in the gnuplot window a spectrum previously saved in the folder indicated via the **Data File Path** parameter. Only the selected trace is set as an Offline trace. This option allows the user to visualize at the same time in the gnuplot window some traces associated to an ongoing acquisition and some traces from a previously saved run or to visualize only offline spectra.
- *Run#*: The command is active only when the Offline option is enabled in the Plot Traces window (see **Fig. 3.6**) and allows the user to select the ID of a previously saved run whose spectrum need to be visualized.
- *Browse*: The command allows the user to visualize in the gnuplot window a previously saved spectrum with any name and any path.

Note: The Offline option allows the user to visualize only the previously saved histograms, not the data from the Binary or ASCII list files (see Sec. **3.6**).

In **Fig. 3.7** an example of gnuplot window with a couple of 22Na ToT spectra visualized is presented. As it is shown, the 1st trace (T0) is associated to the ongoing acquisition on Channel 2 of Board 0, the 2nd (T2) is the result of a previous acquisition of the spectrum of the same source in channel 4. The second trace has been uploaded using offline data, whose file name and path are visible in the gnuplot legend in the top right corner of the window.

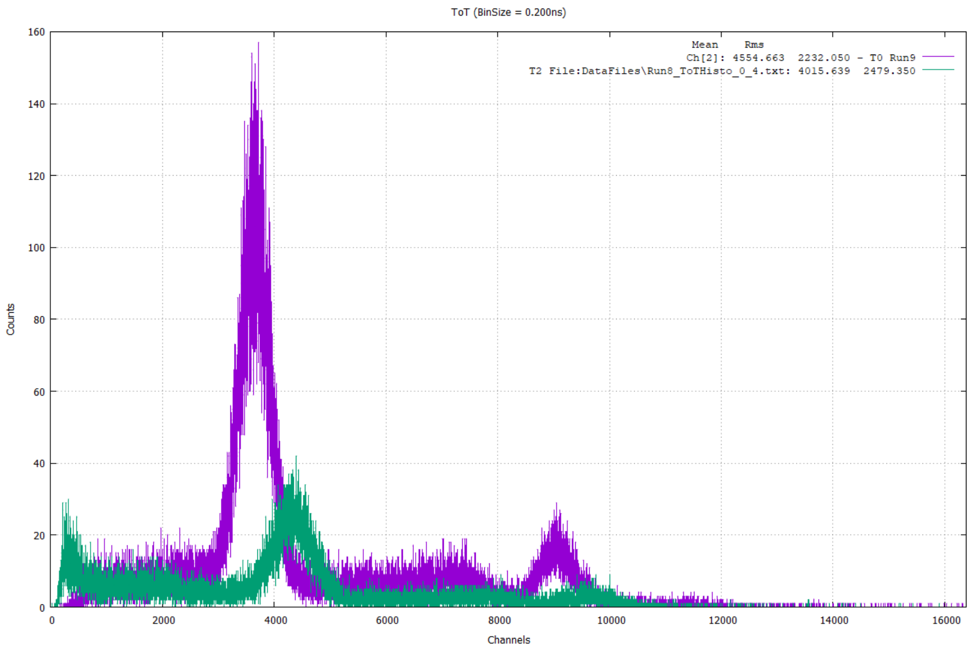


Fig. 3.7: Gnuplot window with online and offline traces visualized.

A matrix is available in the Plot Traces window, where the user can choose the channel/channels to be plotted by selecting one of the following buttons:

- *N*: With N being a number between 0 and 63. The command allows the user to plot the output from channel N for the selected trace.
- *Empty Button*: The button (at the end of each row of channels) allows the user to visualize the 8 traces from the 8 channels in the corresponding row. For instance, if the first Empty Button from the top is pushed, trace T0 will be associated to channel 0, T1 to channel 1, etc.

Note: If the user has selected the trace T0 and suddenly click on the Empty Button, then the 8 visualized traces will be online or offline depending on what option was selected for the trace T0. For instance, if trace T0 is an Offline trace and the user click on the Empty Button then all the 8 traces will be Offline and associated to the same run as that of T0 (e.g. Run1).

- *Calib X-axis*: The command allows the user to enable/disable the calibration of the x-axis (from channels to ns in case of a ToT or ToA histogram). The spectra plots also display the mean and RMS values, expressed in channels or in the calibrated quantity depending on the option chosen.

Save Configuration Button

The Save Configuration command has the same functionality of the *Save Config File As* command of the **File** menu bar item.

Save Run Configuration Button

The Save Run Configuration command allows the user to save the current configuration of parameters in a configuration file named ”Janus_config_RunX.txt”. In this case, X indicates the run number, selected via the **Run#** command. The ”Save Run Configuration” command can be used when the user wants to perform a job composed of several runs (i.e. several consequential acquisitions) with each run corresponding to a different configuration of parameters. In this case, the user has to save for each run of the job a different configuration file. Every time a new run is started during a job, the correspondent configuration file is loaded together with the values of all the parameters. More information on how to perform a job and thus on how to properly use this command are reported in Sec. **3.15**.

Note: Before pressing the **Save Run Configuration Button**, the user should pay attention that the **Enable Jobs** switch is enabled.

Load Configuration Button

The Load Configuration command has the same functionality of the *Read Config File* command of the **File** menu bar item.

Bin to CSV Button

The Bin to CSV command allows the user to convert binary files into CSV files. The user can load a file by clicking on the numbered button 1 and browse to select a file to be converted. One single file has to be added for each row.

In case of multiple files to be converted, the user can write a generic file .txt with the list of names of all the files to be converted, then select the option ”List of binary files names”, and load the list into the row ”1”. As an example, a file called ”File_To_be_converted.txt”, which contains the following rows:

```
Run1_Spect_Lead.bin
Run2_Spect_ToT.bin
Run3_Time.bin
```

can be loaded into the first row and all the .bin files named in that file will be converted.

The option ”Force ToA/ToT to ns” is also available.

Once ready, press the ”Convert” button to convert the selected files.

The source code of the bin to .csv conversion is available in the ”macros” folder.

Fig. 3.8: Binary to CSV converter window.

3.3 Command Bar

A Command Bar is present below the Icon Bar of the Janus 5203 GUI (see **Fig. 3.9**).

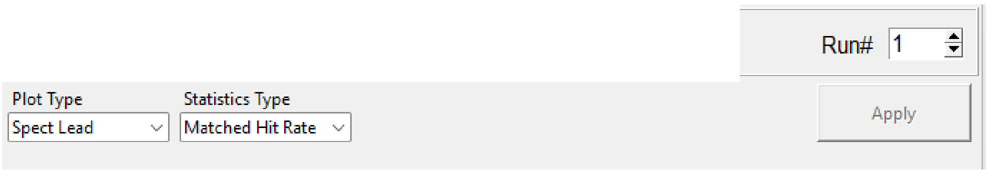


Fig. 3.9: Janus 5203 Command Bar.

Each command corresponds to the following functions.

Plot Type

The Plot Type combo-box allows the user to choose which plot has to be visualized in the gnuplot window. The available options are:

- *Spect Lead*: Leading edge Time of Arrival (ToA) spectrum (X-axis = ToA, Y-axis = Counts).
  In case of Common Start/Stop Acquisition Modes, the ToA is the time elapsed between the leading edge of a T_{ref} signal (defined by the **Tref Source** parameter) and the leading edge of the channels individual hits (see **Fig. 3.10**). In the case of Common Start Mode, the T_{ref} signal arrives before the individual stop hit, so the ToA (which is then a ΔT) is positive. In Common Stop Mode, the T_{ref} signal arrives later and ΔT would be negative, but it is changed sign before being represented in the spectrum.
  In Trigger Matching Mode, the Spect Lead ToA entries are the time difference between the first hit on the channel and following hits received on the same channel, inside the same trigger acquisition window (see left part of **Fig. 3.11**).
  In Streaming Acquisition Mode, the ToA is calculated as the difference between the timestamps of the leading edges of subsequent couples of hits on the same channel (see right part of **Fig. 3.11**).

Note: The ToA data used for the Spect Lead plot in case of Trigger Matching Acquisition Mode are not saved in the list file. The list file contains the ToA given by the time elapsed between the leading edge of the first hit of a channel (matching the trigger window) and the start ot the trigger window.

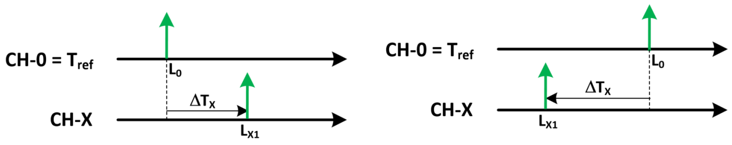


Fig. 3.10: Common Start (*left*) and Common Stop (*right*) Acquisition Mode schemes.

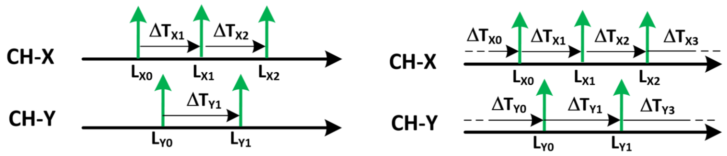


Fig. 3.11: Trigger Matching (*left*) and Streaming (*right*) Acquisition Mode schemes.

The ToA has a dynamic range of up to 24 bits[1] in case of LEAD_ONLY and LEAD_TRAIL Measurement Modes, or 19/16 bits when the ToT8/ToT11 Measurement Modes are enabled. The default LSB is 3.125 ps, the default conversion factor is 1 LSB = 1 bin, and the maximum plot range is truncated to the maximum number of bins which can be selected via the **Lead N Channels** parameter. The LSB and the conversion factor can be modified via the **Lead/Trail LSB** and **Lead Rebin** parameters, respectively. The minimum range of the histogram can be changed via the **Lead Histo Min** parameter.
Refer to Sec. **3.10** for more details.

- *Spect ToT*. Time over Threshold spectrum (X-axis = ToT, Y-axis = Counts).
  The ToT measurement is saved on 8/11 bits (for the ToT8 and ToT11 Measurement Modes respectively), so the spectrum is composed of 256/2048 channels, given the default conversion factor 1 LSB = 1 bin. The maximum ToT dynamic is therefore 0.8/6.4 ns (1 LSB = 3.125 ps) in case of no histogram rebinning. As for the case of the Spect Lead, the Spect ToT histogram parameters can be modified.
  Refer to Sec. **3.10** for more details.
  This Plot Type is not used in case of LEAD_ONLY Measurement Mode.
- *Total Cps*: Histogram of the total number of counts per second per channel (X-axis = Channel number from 0 to 63, Y-axis = Counts per Second). The entries of the plot are the hit counts read by the picoTDC chip, not the counts of all the hits arriving at the picoTDC input channels.

Note: The entries of the plots reflects the data saved in the list data files (except for the Trigger Matching Acquisition Mode).

Note: As to reduce the readout bandwith occupancy, the user can disable the Spect Lead, Spect Trail and Spect ToT plots via the **Lead N Channels** and **ToT N Channels** parameters.

[1] 64 bits in case of Streaming Acquisition Mode

Statistics Type

The Statistics Type command allows the user to choose between the different values to be displayed in the Stats Tab (Sec. **3.13**) for each channel. Available options are:

- *Matched Hit Rate*: Channels hits rate matching the reference trigger and the acquisition criteria.
- *Matched Hit Cnt*: Channels hits count matching the reference trigger and the acquisition criteria.
- *Read Hit Rate*: Channels read hits rate.
- *Read Hit Cnt*: Channels read hits count.
- *Lead Mean*: Mean value of the Lead ToA.
- *Lead RMS*: RMS value of the Lead ToA.
- *ToT Mean*: Mean value of the ToT (not working for LEAD_ONLY Measurement Modes)
- *ToT RMS*: RMS value of the ToT (not working for LEAD_ONLY Measurement Modes)

For a better understanding of the ”Matched” and ”Read” hits refer to **Fig. 3.12**.

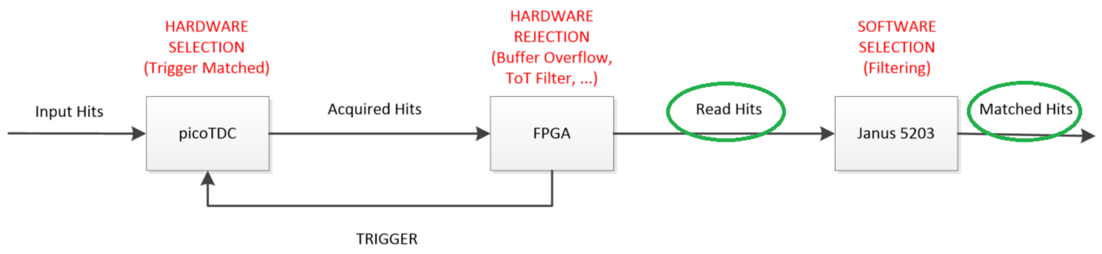


Fig. 3.12: Schematic representation of the hits data flow in the A5203(B)/DT5203 unit. The Read and Matched Hits (used for statistics) are circled in green.

Run#

The Run# command defines the ID number of the current run.

Apply Button

The button allows the user to save the current settings for all parameters. Every time the value of a parameter is changed, the button becomes red. The user has to press the button in order to let the changes become effective, i.e. to overwrite the ”Janus_Config.txt” file parsed by the ”JanusC.exe” application.

3.4 Status Bar

The Status Bar in the bottom part of the Janus 5203 GUI displays basic information regarding the connection, the Run status and the board buffer Almost Full (AF) condition. In **Fig. 3.13** different configurations of the Status Bar are visible. From the top to the bottom the presented configurations are:

- The Janus 5203 GUI is connected to the JanusC.exe application and the boards are connected.
- The acquisition is ongoing.
- The acquisition is ongoing and the board buffer is in an Almost Full condition.
- The Janus 5203 GUI is connected, but there is some WARNING (visible in the Log). However, the Run is ready to start.

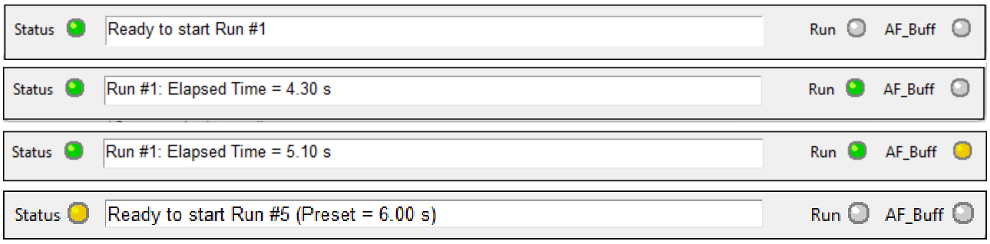


Fig. 3.13: Janus 5203 Status Bar.

3.5 Connect Tab

The Connect tab allows the user to set the connection properties of the FERS-5200 boards. Once one or more boards are connected, also information regarding the board identification number (PID) and firmware releases are displayed (see **Fig. 3.14**). The number on the left of the PATH field defines the board ID number assigned by the software (between 0 and 15) once the board is connected.

PATH

This field allows the user to define the type of connection for the board.
If using a **USB connection** there are two ways to connect the board:

1. By writing down the "usb:PID" string, being PID the board identification number that is located either on the top of the A5203(B) PCB or on the bottom panel of the DT5203.
2. By writing down the "usb:N" string, with N being an incremental number from 0 to 15.

Note: In case of a multi-board USB connection (see Sec. **3.5.1**), the option 1 is suggested to the user.

If using an **Ethernet connection** the user should write down "eth:IP_ADDR", being IP_ADDR the IP address of the board. By default, the IP address is 192.168.50.3, so that the user should write down "**eth:192.168.50.3**" for the PATH fied.

Note: The user can change the Ethernet IP address by accessing the FERS-5200 Web Interface (see Sec. **3.5.1**). Note that the web interface is not accessible with USB connection.

In case of **TDlink connection** via the DT5215 Concentrator Board (single or multi board), the available options are:

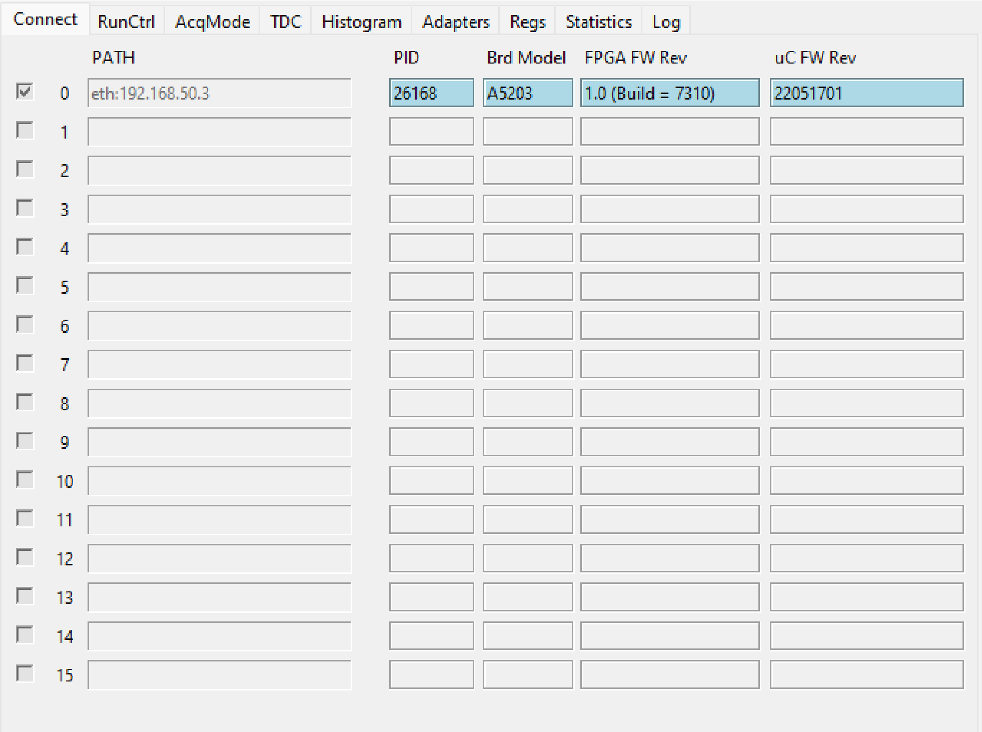


Fig. 3.14: Connect Tab.

- ”usb:IP_ADDR:tdl:x:y”, where IP_ADDR is the IP address for the USB connection to the DT5215, tdl=TDlink is the type of FERS-5200 board connection to the DT5215, and x and y the link number and board number, respectively. The default IP address of the DT5215 USB connection is: **172.16.0.11**.
- ”eth:IP_ADDR:tdl:x:y”, where IP_ADDR is the IP address for the ethernet connection to the DT5215, tdl=TDlink is the type of FERS-5200 board connection to the DT5215, and x and y the link number and board number, respectively. The default IP address of the DT5215 Ethernet connection is **192.168.50.125**.

For a single board connection to the TDlink, x=0 and y=0. For a multi board connection, refer to Sec. **3.5.1**.

In order to establish a connection with the ”JanusC.exe” application, the user has then to click on the Connect button on the top left part of the Janus 5203 GUI window .
Once the connection with the board is established (see **Fig. 3.15**), the following board parameters are visualized in the Tab:

- **PID**: The exclusive identification number associated to the specific board connected.
- **Brd Model**: The board model, between A5203 and DT5203.
- **FPGA FW Rev**: The FPGA firmware revision.
- **uC FW Rev**: The micro controller firmware revision.

Fig. 3.15: Janus 5203 interface when the connection in established.

3.5.1 Multi-Board Connection

The aim of this section is to describe how to perform a multi-board connection to the same PC in Janus 5203. Indeed, the software allows the user to connect up to 16 boards via Ethernet or via USB in order to control them and acquire data from all of them at the same time.

The connection PATHs should be written one after the other, starting from the first line (board number 0). As to enable the connection to the boards 1-15, the user should write the corresponding PATH and tick the box on the left side of the PATH.

Note: The PATH fields must be filled progressively.

Ethernet Connection

To control more than one board with the Janus 5203 software via an Ethernet connection the user can take advantage, for instance, of an Ethernet switch. Then, an IP address reassignment of all the boards that are needed to be connected is necessary. The user is kindly suggested to follow the instructions below in order to properly perform a multi-board Ethernet connection:

1. Connect only one board to the PC via an Ethernet cable.
2. Open the Web Interface (see A5203(B)/DT5203 User Manual **[RD1]**) at the default IP address of the board, i.e. ”192.168.50.3” if this was not previously changed via the Web Interface.
3. Open the Configuration Tab of the Web Interface (see **Fig. 3.16**) and select for the ”IP address” parameter a value different from the IP address set for the PC. For instance, in the A5203(B)/DT5203 User Manual **[RD1]**, the IP address of the PC was set to be ”192.168.50.4”. For this reason, the ”192.168.50.2” IP address was chosen in this example.

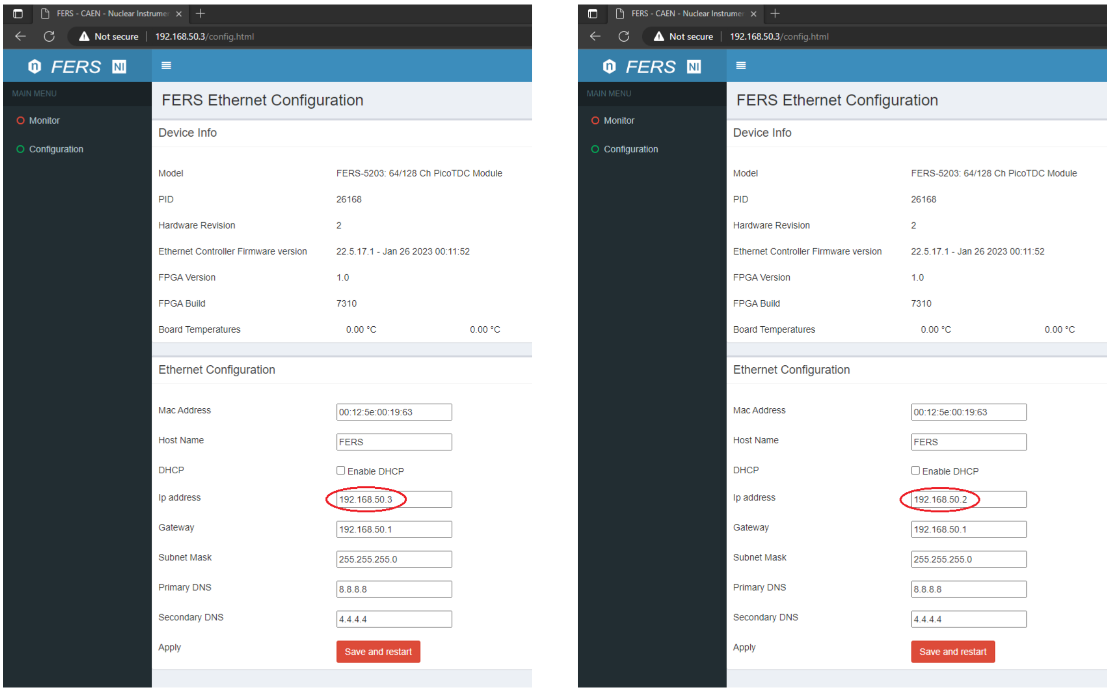


Fig. 3.16: Configuration Tab of the A5203(BB)/DT5203 Web Interface, with default settings on the left and modified IP address on the right.

4. Press on the Save and Restart button in the bottom part of the Tab, a message like that shown in **Fig. 3.17** will be displayed. The A5203(B)/DT5203 board has been assigned with the selected IP address.

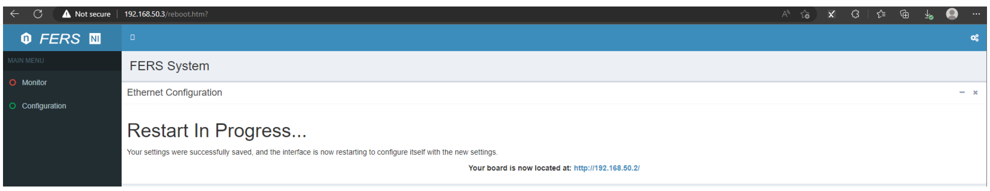


Fig. 3.17: Displayed message once the IP address of the board has been correctly changed.

5. The user can check that the connection is established by trying to ping the board via the Command Prompt (see **Fig. 3.18**) and checking the displayed message.

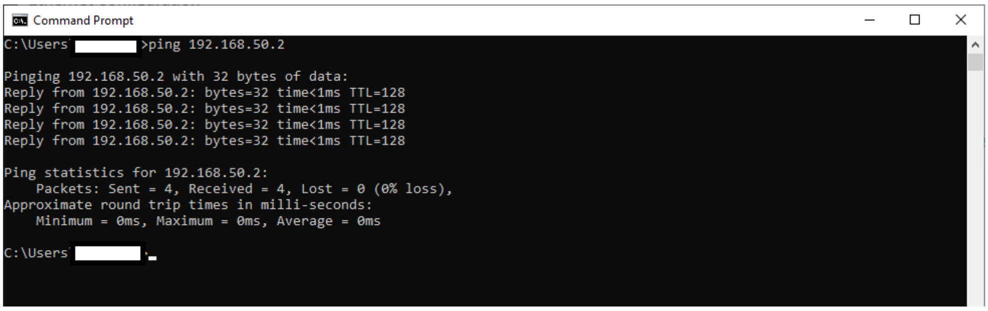


Fig. 3.18: Command prompt window with the command for testing the communication at the selected IP address.

6. The user should repeat the instructions above as many times as there are boards he/she wants to connect.

Note: Every board should have a different IP address with respect to the other boards and to the PC.

7. Connect the boards and the PC to the ports of an Ethernet switch for instance.
8. Open the Janus 5203 GUI. The IP addresses of all the boards have to be written in the PATH fields one below the other. The Connect button can then be pressed. An example of a two-board Ethernet connection is presented in **Fig. 3.19**.

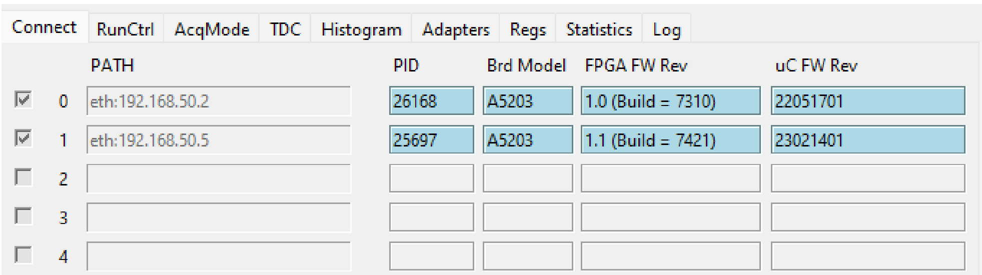


Fig. 3.19: The Janus 5203 GUI Connect Tab with a two-board Ethernet connection established.

USB Connection

In order to connect N boards via USB, the user can take advantage of an USB hub or alternatively use N USB ports of a single PC. The user should then follow the instructions below:

1. Connect all the boards via USB directly to the PC or via an USB hub.
2. Write down in the PATH field for each board "usb:PID", being PID the board unique identification number that is located either on the top of the A5203(B) PCB or on the bottom panel of the DT5203. Alternatively, the user should write down in the PATH field for each board the "usb:N" string, being N a progressive number ranging from 0 to 15 and depending on the number of boards which needs to be connected at the same time. An example of a two-board USB connection is presented in **Fig. 3.20**.

Note: The user can also perform a "mixed" connection by connecting some boards via Ethernet and others via USB.

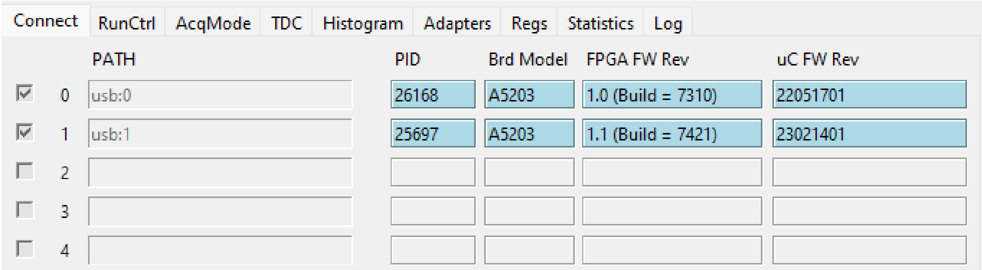


Fig. 3.20: The Janus 5203 GUI Connect Tab with a two-board USB connection established.

TDlink Connection

Multiple A5203(B)/DT5203 can be connected to Janus 5203 thanks to the TDlink connection of the DT5215 Concentrator Board **[RD3]**. Each TDlink supports the connection of an individual board, or of multiple boards (up to 16) in daisy chain.
In case of a daisy-chain multi-board connection on a single DT5215 TDlink (see **Fig. 3.21**), the path of each board of the chain present a different board number y (see the PATH written in the previous lines), depending on the position of the board on the chain.
In case of single board connections on different TDlinks (see **Fig. 3.22**), the path of each board presents a different TDlink number x (see the PATH written in the previous lines), depending on the TDlink used. For further instructions on the TDlink connection, refer to **[RD3]**.

Note: As to perform a Janus 5203 connection to the TDlinks 1-7, they must be enabled in the DT5215 Web Interface **[RD3]**. The TDLinks must be sequentially enabled, starting from TDlink 0. Only effectively used TDlink must be enabled.

Note:The Janus 5203 GUI supports the connection of up to 16 FERS units. If more FERS units need to be connected, the user must act on the MAX_NBRD parameter in the JanusC.h source code, compile the entire solution, and run in Console Mode (see Sec. **4**).

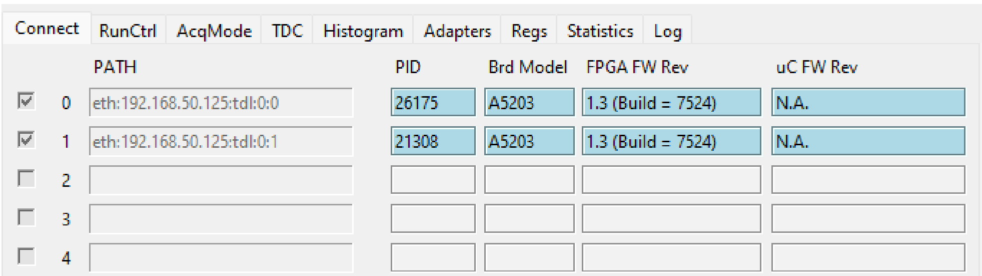


Fig. 3.21: The Janus 5203 GUI Connect Tab with a two-board TDlink connection to the DT5215, connected via Ethernet to the PC, in case of boards connected in daisy-chain.

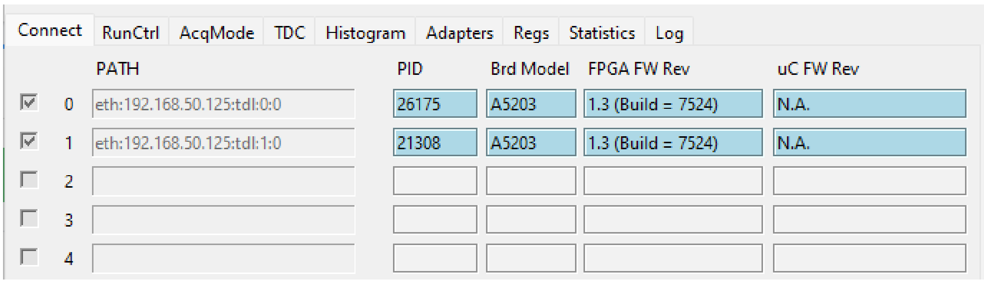


Fig. 3.22: The Janus 5203 GUI Connect Tab with a two-board TDlink connection to the DT5215, connected via Ethernet to the PC. Each board is connected individually to a TDlink.

3.6 RunCtrl Tab

The RunCtrl Tab allows the user to set the value of all the parameters managing the acquisition run and the format of the output files to be saved (see **Fig. 3.23**).

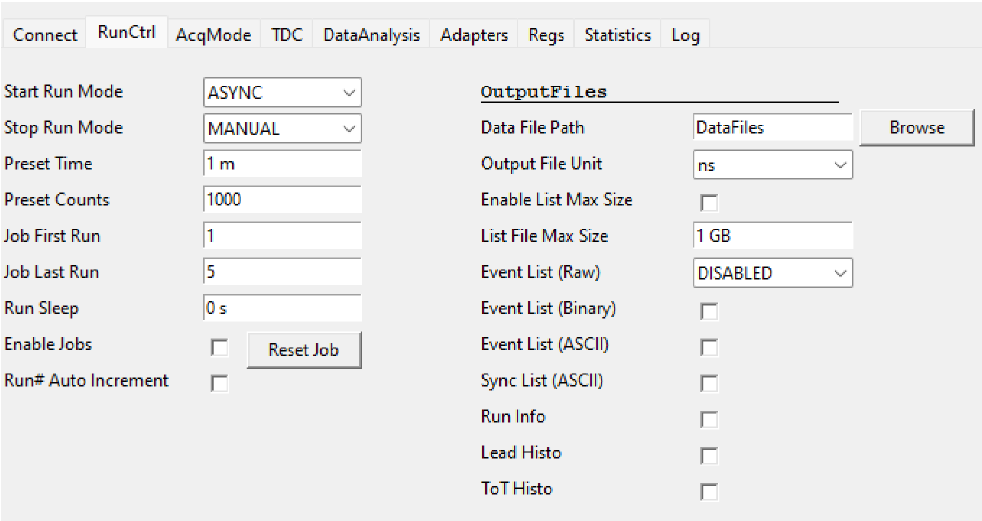


Fig. 3.23: Run Control Tab.

Start Run Mode

The command defines the source used to start the acquisition. The available options are:

- *ASYNC*. An asynchronous (between the connected boards) software command, i.e. from the **Start Button**, is used to start the acquisition.
- *CHAIN_T0*. The I/O T0 connector chain is used to transmit the Run signal **[RD1]**, which is in turn used as start acquisition signal, to several boards. If the start run signal has to be transmitted to N connected boards, the user should connect the T0-OUT connector of the i^{th} board to the T0-IN connector of the $i{+}1^{th}$ board, with i ranging from 1 to N-1. Then, the user should press the **Start Button** in order to start the acquisition on the board connected as Board 0 in the Janus 5203 software. The acquisition on the other boards will begin in cascade with a delay, between the start of the acquisition on the i^{th} board and that on the $i{+}1^{th}$, of approximately 25 ns (2 FPGA clock cycles) summed to the signal delay provided by the connection cables.
- *CHAIN_T1*. The I/O T1 connector chain is used to transmit the Run signal **[RD1]**, which is in turn used as start acquisition signal, to several boards. See ”CHAIN_T0” above for further details.

Note: When the ”CHAIN_T0”/”CHAIN_T1” option is chosen for the **Start Run Mode** parameter, the option chosen for the **T0-OUT/T1-OUT** parameter is overwritten.

- *TDL*. In this case, the start command is a synchronous signal propagated via the Optical Link TDlink to all the boards (connected in daisy-chain) and managed by the FERS-5200 Concentrator Board DT5215.

Stop Run Mode

The command defines the source used to stop the acquisition. The available options are:

- *MANUAL*. A software command (sent after pressing the **Stop Button**) is used to stop the acquisition. This command is not available if jobs are enabled (via the **Enable Jobs** parameter).
- *PRESET_TIME*. The run is stopped after a time interval determined by the **Preset Time** parameter.

- *PRESET_COUNTS*. The run is stopped when a programmable number of events, determined via the **Preset Counts** parameter, has been acquired.

Note: in case of TDL Start Run Mode, the Stop Run is given synchronously to all the boards connected (in daisy chain), and managed by the DT5215.

Preset Time

The value set for this parameter defines the length of the run when the ”PRESET_TIME” option is selected for the **Stop Run Mode** parameter.

Preset Counts

The value set for this parameter defines the number of events composing the run when the ”PRESET_COUNTS” option is selected for the **Stop Run Mode** parameter.

Job First Run

The value set for this parameter defines the ID number of the first run of a series of runs, i.e. of a job.

Job Last Run

The value set for this parameter defines the ID number of the last run of the job.

Run Sleep

The command defines the time interval (expressed in s) between consecutive runs.

Enable Jobs

This switch allows the user to enable/disable the job structure of the acquisition (i.e. consecutive runs performed within the same acquisition). The run ID is automatically incremented when working with this option enabled and varies from the value set for the **Job First Run** to the value set for the **Job Last Run** parameter. More information on how to perform a job and thus on how to properly use this command are reported in Sec. **3.15**.

Reset Job

This button allows the user to interrupt the entire job and start over. If the user press the **Stop Button** from the ”Icon bar”, only the current run of the job is stopped.

Run# Auto Increment

This switch allows the user to enable/disable the automatic incrementation of the run number ID. Every time a run is stopped, the ID number for the next run is incremented.

3.6.1 Output Files Section

Data File Path

The command defines the destination folder where the data files are saved. Default location is ”DataFiles” folder under ”bin”. The user can modify the path by clicking on the ”Browse” button.

Note: The user should take care of having writing permissions on the destination folder inserted.

Output File Unit

The command defines units of ToA and ToT saved into file. The available options are:

- *LSB*. One LSB corresponds, by default, to 3.125 ps. The LSB value can be changed in the Histogram Tab, via the **Lead/Trail LSB** and **ToT LSB** parameters, for the ToA and ToT LSB, respectively. Refer to Sec. **3.10** for more details.

- *ns*. Time is saved in ns time unit (32 bits float numbers[2]).

Enable List Max Size

The command permits to enable/disable saving event list files with a maximum size. The size is defined via the **List File Max Size** parameter.

List File Max Size

The value set for this parameter (in bytes and multiples) defines the maximum size allowed for the saved list files. The minimum accpeted vales is 1 kB.
The saving of maximum size list files must be enabled via the **Enable List Max Size** parameter.

Event List (Raw)

The options for this parameter are: DISABLED, SAVE, LOAD. The selection of one of the options permits to, respectively, disable the raw data files saving, enable the raw data files saving, and read and process raw data files previously saved.

Event List (Binary)

The command enables/disables the saving of the event list in binary format. One file is saved (with the data acquired from all boards) with the name ”RunX_List.dat”, being X the run number. The complete description of the binary data format for the different acquisition modes is presented in Sec. **3.7.1**.

Event List (ASCII)

The command enables/disables the saving of the event list in ASCII format. One list file is produced for each run with the name ”RunX_List.txt”, being X the run number. The complete description of the ASCII data format for the different acquisition modes is presented in Sec. **3.7.2**.

Sync List (ASCII)

The command enables/disables the saving of the event list in ASCII format writing just few information with respect to the **Event List (ASCII)**, like the board number, trigger time stamp (us), and the trigger ID. This file can be useful to check the alignnment of the events across multiple boards. One list file is produced for each run with the name ”RunX_Sync.txt”, being X the run number.

Run Info

The command enables/disables the saving of a file containing a summary of the run, like the run number, start/stop time of the measurement, firmware and software versions, and the configuration parameters.

Lead Histo

The command enables/disables saving data of the Lead Histo. The histograms are saved as a single column text file for each channel.

[2] The ToA is saved as a 64 bits double number in case of Streming Acquisition Mode.

ToT Histo

The command enables/disables saving data of the ToT spectra. The histograms are saved as a single column text file for each channel.

3.7 Data Format

Starting from Janus 5203 software release ≥ 2.4.0, the data format has been modified according the description below. Data format version is 3.2.

3.7.1 Binary Format

Header structure

In binary format, each file is composed by a header containing the information regarding the data format, software and FERS version, the acquisition mode and the time stamp of the start of the acquisition:

FILE HEADER	
Data Format Version	(int, 16 bits)
Software Version	(int, 24 bits)
FERS Version	(int, 16 bits)
Run Number	(int, 16 bits)
Acq Mode	(int, 16 bits)
Meas Mode	(int, 8 bits)
Time Unit	(int, 8 bits)
ToA LSB Value	(float, 32 bits)
ToT LSB Value	(float, 32 bits)
Timestamp LSB Value	(float, 32 bits)
Start Run (ms)	(int, 64 bits)

For the *Acquisition Mode* information, the available values are:

- *0x02* for Common Start;
- *0x12* for Common Stop;
- *0x22* for Streaming;
- *0x32* for Trigger Matching;
- *0x01* Test Mode (1 hit per channel).

For the *Measurement Mode* information, the available values are:

- *0x01* for LEAD_ONLY;
- *0x03* for LEAD_TRAIL;
- *0x05* for LEAD_TOT8;
- *0x09* for LEAD_TOT11.

Time unit can be:

- *0x00* for the time expressed in LSB (ToA should be read as uint32 and ToT as uint16 in Common Start, Common Stop and Trigger Matching Acquisition Modes, while it should be read as uint64 and ToT as uint16 in Streaming Acquisition Mode);
- *0x01* for the time expressed in ns (ToA and ToT should be read as float numbers in all the Acquisition Modes, except for the Straming Acquisition Mode in which the ToA is a double number).

ToA/ToT/Timestamp LSB Value is the conversion value between LSB and ps for the ToA/ToT/Timestamp timing information. This value depends on the LSB value selected in the Histogram Tab (see Sec **3.10**) for the ToA and ToT, and it is fixed at 12.8 ns for the Timestamp. The Timestamp LSB value is, then, expressed in FPGA clock time units. Refer to the A5203(B)/DT5203 User Manual **[RD1]** for more details.

The *Start Run* information is expressed in ms with reference to the UnixEpoch time.

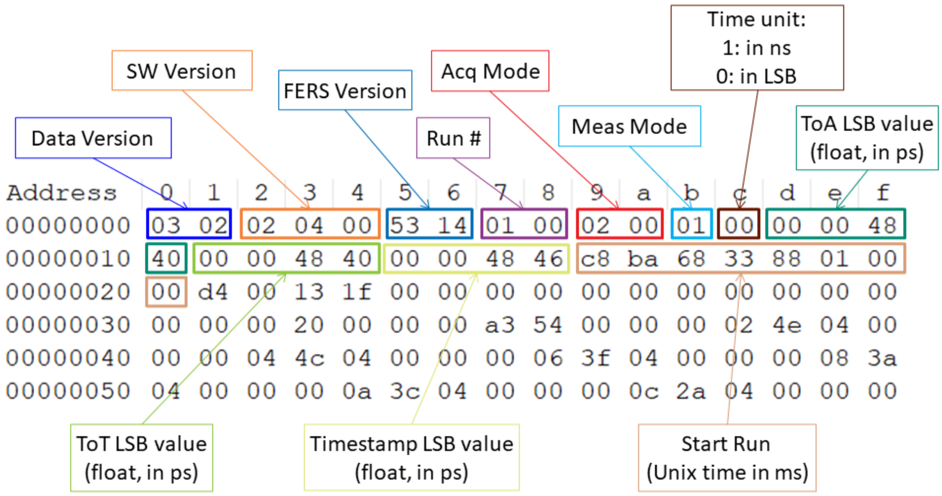


Fig. 3.24: File header example (binary format).

In **Fig. 3.24** an example of a file header in binary format is presented. The colors (the same used in the data format description) correspond to:

- Blue = Data Format Version = 0x0302 = 3.2
- Orange = Software Version = 0x020400 = 2.4.0
- Navy Blue = FERS Version = 0x1453 = 5203
- Fuchsia = Run Number = 0x0001 = 1
- Red = Acquisition Mode = 0x0002 = Common Start Mode
- Cyan = Measurement Mode = 0x01 = LEAD_ONLY Mode
- Sepia = Time Unit = 0x00 = Time in LSB
- Pine Green = ToA LSB value (float) = 0x40480000 = 3.125 ps
- Lime Green = ToT LSB value (float) = 0x40480000 = 3.125 ps
- Green Yellow = Timestamp LSB value (float) = 0x46480000 = 12800 ps
- Tan = Start Run = 0x000001883368BAC8 = 1684489681608 ms

The data format for the remaining part of the file depends on the particular Acquisition Mode and Measurement Mode selected. However, regardless of the Acquisition and Measurement Modes, each event is constituted by a Header and a Data part.

Common Start/ Common Stop Mode

The Common Start/Common Stop Acquisition Modes can be performed in the four different Measurement Modes described in Sec. **3.8**. The structure of the Common Start event recorded (the Common Stop event presents the same data format), for the relative Measurement Mode, is described below:

EVENT HEADER	
Event Size (byte)	(int, 16 bits)
Trigger Time Stamp (µs)	(double, 64 bits in µs/int, 64 bits in LSB)
Trigger ID	(int, 64 bits)
Number of hits	(int, 16 bits)
Board ID	(int, 8 bits)
Channel ID	(int, 8 bits)
ToA	(float, 32 bits in ns/int, 32 bits in LSB)
ToT	(float, 32 bits in ns/int, 16 bits in LSB)

Note: The ”Event Size” information also includes the size of the variable itself, i.e. 2 bytes.

Note: The ToT information is not available for the LEAD_ONLY Measurement Mode.

Note: The ToT information in LSB units is always written over 16 bits. In LEAD_TRAIL Measurement Mode, all the 16 bits are used, in LEAD_TOT8 and LEAD_TOT11, the remaining 8 and 5 bits are set to 0.

In **Fig. 3.25**, **3.26**, **3.27** an example of data files in binary format of Common Start data in LEAD_ONLY, LEAD_TRAIL and LEAD_TOT8-11 Measurement Modes are presented.

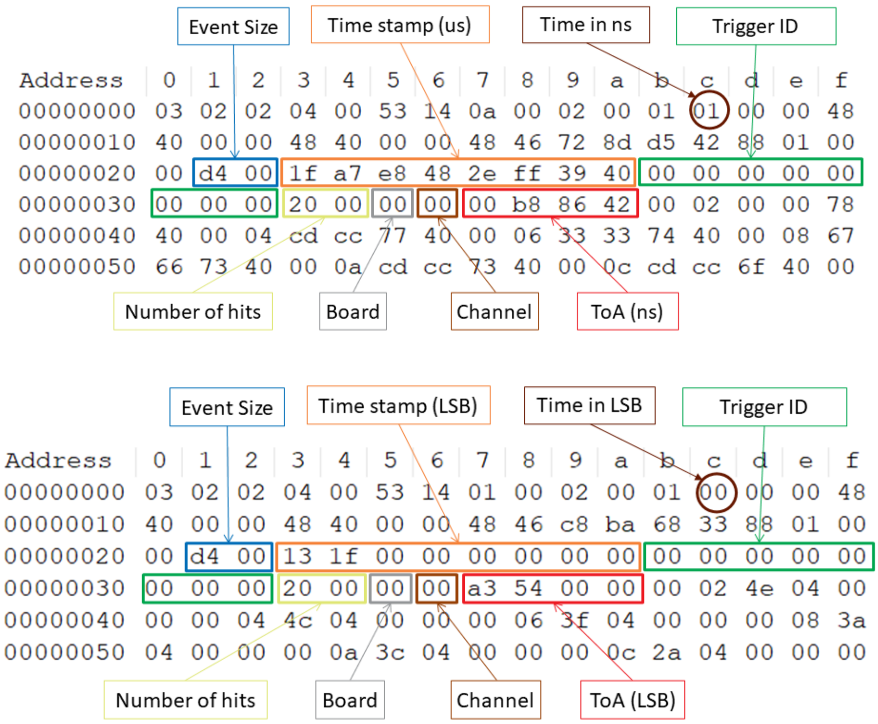


Fig. 3.25: Event List example in Common Start - LEAD_ONLY (binary format) in ns (*top*), and in LSB (*bottom*) time units.

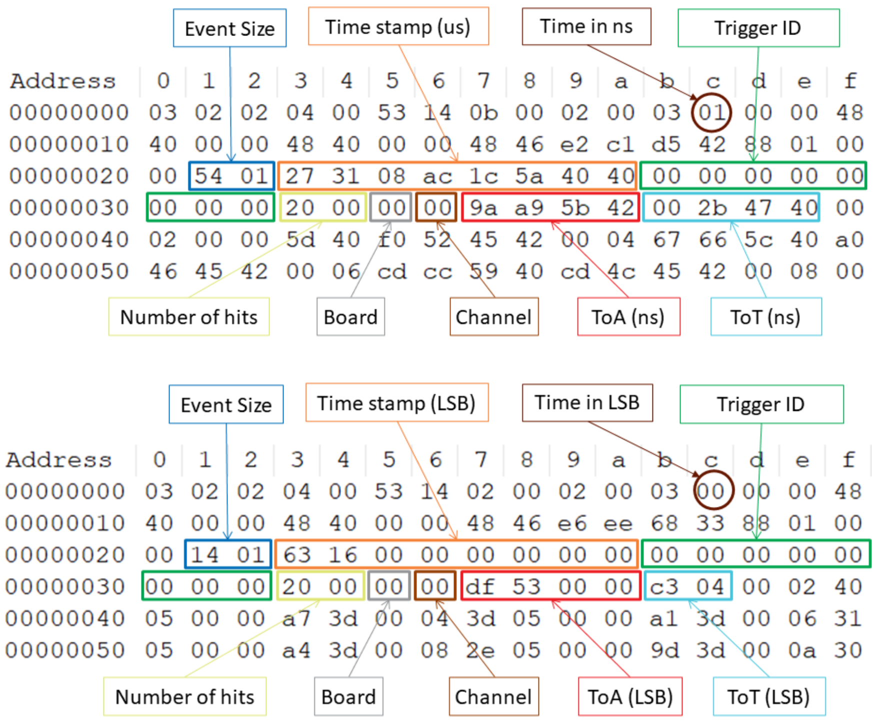


Fig. 3.26: Event List example in Common Start - LEAD_TRAIL (binary format) in ns (*top*), and in LSB (*bottom*) time units.

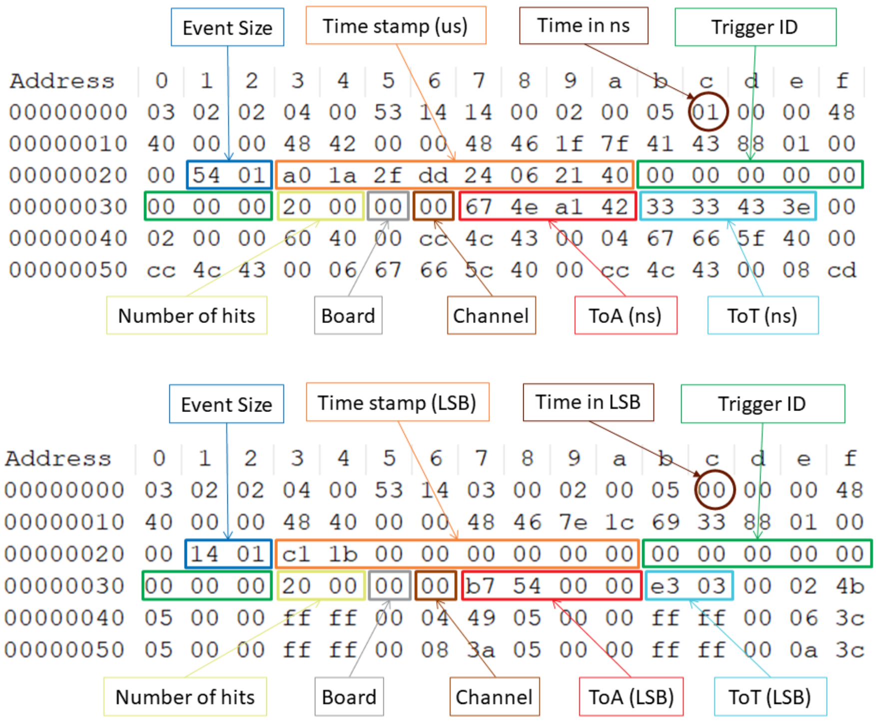


Fig. 3.27: Event List example in Common Start - LEAD_TOT8/11 (binary format) in ns (*top*), and in LSB (*bottom*) time units.

Referring to **Fig. 3.26**, the colors (the same used in the data format description) correspond to:

- NavyBlue = Event Size = 0x0154 = 320 (dec) bytes
- Orange = Trigger Time Stamp = 0x40405A1CAC083127 = 32.7040 (dec) µs
- Red = Trigger ID = 0
- GreenYellow = Number of hits = 0x20 = 32
- Gray = Board ID = 0
- RawSienna = Channel ID = 0
- Red = ToA = 0x425BA99A = 54.916 ns
- SkyBlue = ToT = 0x40472B00 = 3.112 ns

in case of ns time units, and to

- NavyBlue = Event Size = 0x0114 = 276 (dec) bytes
- Orange = Trigger Time Stamp = 0x1663 = 5731 LSB
- Red = Trigger ID = 0
- GreenYellow = Number of hits = 0x20 = 32
- Gray = Board ID = 0
- RawSienna = Channel ID = 0
- Red = ToA = 0x53DF = 21471 LSB
- SkyBlue = ToT = 0x04C3 = 1219 LSB

in case of LSB time units.

Trigger Matching Mode

The structure of the event recorded in Trigger Matching Acquisition Mode, for all the possible Measurement Modes, is described below:

EVENT HEADER	
Event Size (bytes)	(int, 16 bits)
Trigger Time Stamp (µs)	(double, 64 bits in µs - int, 64 bits in LSB)
Trigger ID	(int, 64 bits)
Number of Hits	(int, 16 bits)
Board ID	(int, 8 bits)
Channel ID	(int, 8 bits)
Edge	(int, 8 bits)
ToA (ch)	(float, 32 bits if ns - int, 32 bit if LSB)
ToT (ch)	(float, 32 bits if ns - int, 16 bit if LSB)

The available options for the ”Edge” information are:

- 0x0, the trailing edge of the input signal is acquired for the ToA (only in LEAD_TRAIL Measurement Mode).
- 0x1, the leading edge of the input signal is acquired for the ToA.

Note: The ”Event Size” information also includes the size of the variable itself, i.e. 2 bytes.

Note: The ToT information is not available for the LEAD_ONLY Measurement Mode.

In **Fig. 3.28**, **3.29**, **3.30** an example of data files in binary format of Trigger Matching data in LEAD_ONLY, LEAD_TRAIL and LEAD_TOT8-11 Measurement Modes are presented.

Referring to **Fig. 3.29**, the colors (the same used in the data format description) correspond to:

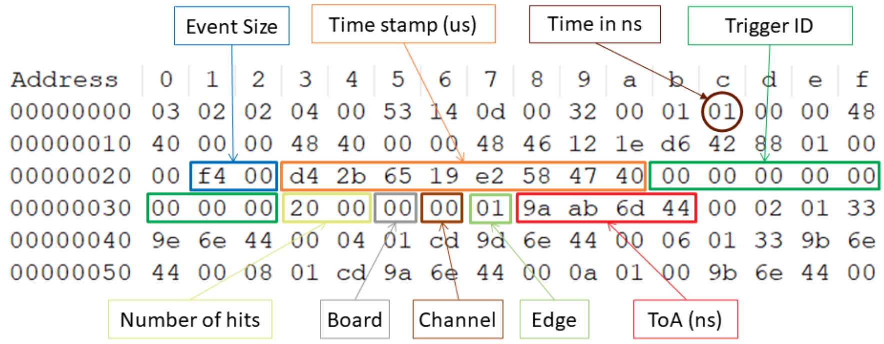
- NavyBlue = Event Size = 0x2DF = 735 (dec) bytes
- Orange = Trigger Time Stamp = 0x40465604189374BC = 44.672 µs
- Green = Trigger ID = 0
- GreenYellow = Number of Hits = 0x41 = 65 (dec)
- Gray = Board ID = 0 (dec)
- RawSienna = Channel ID = 0 (dec)
- YellowGreen = Edge = 0x1
- Red = ToA = 0x446A6167 = 937.522 ns
- SkyBlue = ToT = 0x0 = 0 ns

in case of ns time units, and to

- NavyBlue = Event Size = 0x25D = 605 (dec) bytes
- Orange = Trigger Time Stamp = 0x4D0 = 1232 (dec) LSB (= 15.7696 µs)

- Green = Trigger ID = 0
- GreenYellow = Number of Hits = 0x41 = 65 (dec)
- Gray = Board ID = 0 (dec)
- RawSienna = Channel ID = 0 (dec)
- YellowGreen = Edge = 0x1
- Red = ToA = 0x4927F = 299647 (dec) LSB (= 936396.875 ns)
- SkyBlue = ToT = 0x0 = 0 (dec) LSB (= 0 ns)

in case of LSB time units.



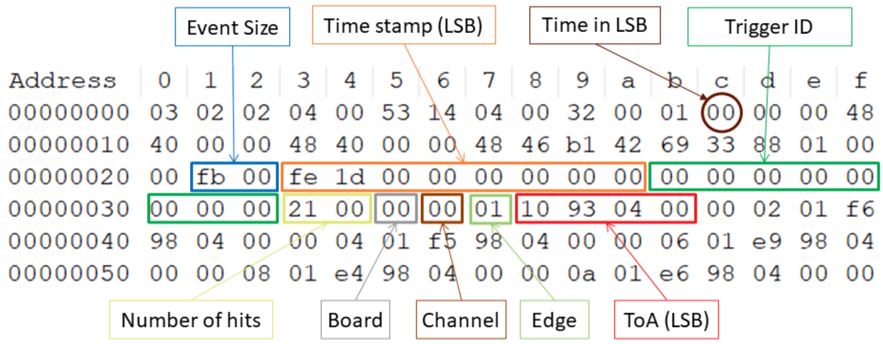


Fig. 3.28: Event List example in Trigger Matching - LEAD_ONLY (binary format) in ns (*top*), and in LSB (*bottom*) time units.

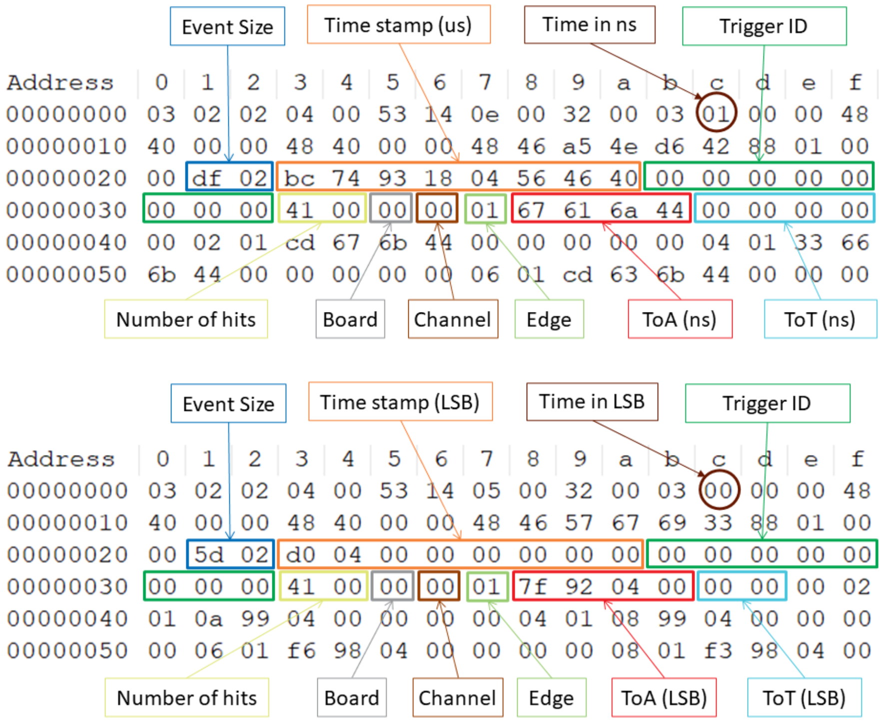


Fig. 3.29: Event List example in Trigger Matching - LEAD_TRAIL (binary format) in ns (*top*), and in LSB (*bottom*) time units.

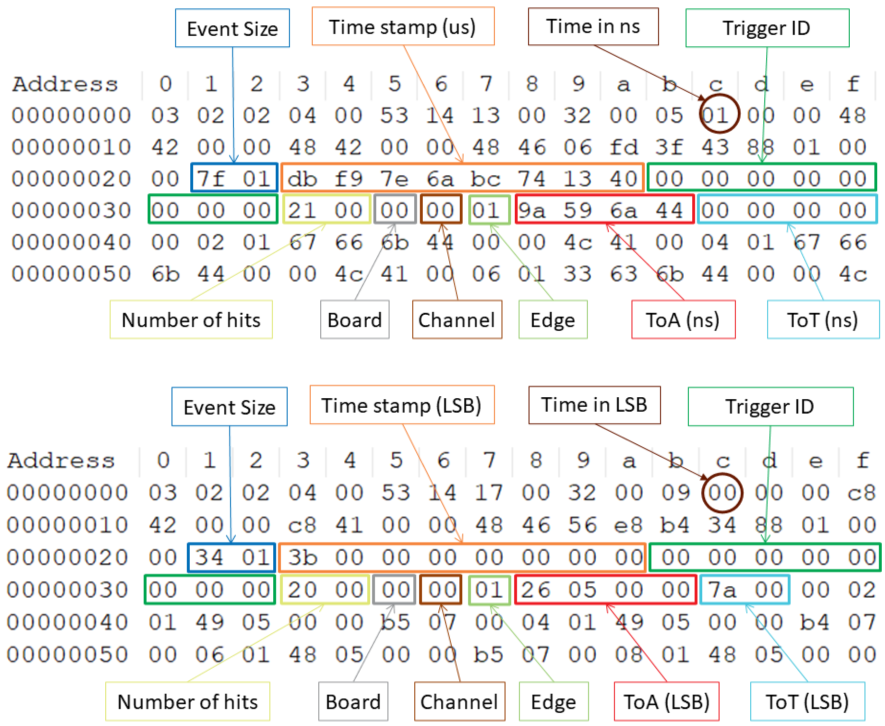


Fig. 3.30: Event List example in Trigger Matching- LEAD_TOT8/11 (binary format) in ns (*top*), and in LSB (*bottom*) time units.

Streaming Mode

The structure of the event recorded in Streaming Acquisition Mode, for all the possible Measurement Modes, is described below:

EVENT HEADER

Event Size (bytes) (int, 16 bits)

Trigger Time Stamp (µs) (double, 64 bits in µs - int, 64 bits in LSB)

Number of Hits (int, 16 bits)

Board ID (int, 8 bits)

Channel ID (int, 8 bits)

Edge (int, 8 bits)

ToA (ch) (double, 64 bits if ns - int, 64 bit if LSB)

ToT (ch) (float, 32 bits if ns - int, 16 bit if LSB)

The available options for the "Edge" information are:

- 0x0, the trailing edge of the input signal is acquired for the ToA (only in LEAD_TRAIL Measurement Mode).
- 0x1, the leading edge of the input signal is acquired for the ToA.

Note: The "Event Size" information also includes the size of the variable itself, i.e. 2 bytes.

Note: The ToT information is available for the LEAD_TRAIL Measurement Mode only.

In **Fig. 3.31**, **3.32** an example of data files in binary format of Trigger Matching data in LEAD_ONLY, LEAD_TRAIL and LEAD_TOT8-11 Measurement Modes are presented.

Referring to **Fig. 3.32**, the colors (the same used in the data format description) correspond to:

- NavyBlue = Event Size = 0x3CC = 972 (dec) bytes
- Orange = Trigger Time Stamp = 0x40368A71DE69AD44 = 22.541 µs
- GreenYellow = Number of Hits = 0x40 = 64 (dec)
- Gray = Board ID = 0 (dec)
- RawSienna = Channel ID = 0 (dec)
- YellowGreen = Edge = 0x1
- Red = ToA = 0x40D78DA739169D00 = 24118.613 ns
- SkyBlue = ToT = 0x0 = 0 ns

in case of ns time units, and to

- NavyBlue = Event Size = 0x359 = 857 (dec) bytes
- Orange = Trigger Time Stamp = 0x761 = 1889 (dec) LSB (= 24.1792 µs)
- Green = Trigger ID = 0
- GreenYellow = Number of Hits = 0x41 = 65 (dec)

- Gray = Board ID = 0 (dec)
- RawSienna = Channel ID = 0 (dec)
- YellowGreen = Edge = 0x1
- Red = ToA = 0xC6F2BD = 13038269 (dec) LSB (= 40744590.625 ns)
- SkyBlue = ToT = 0x0 = 0 (dec) LSB (= 0 ns)

in case of LSB time units.

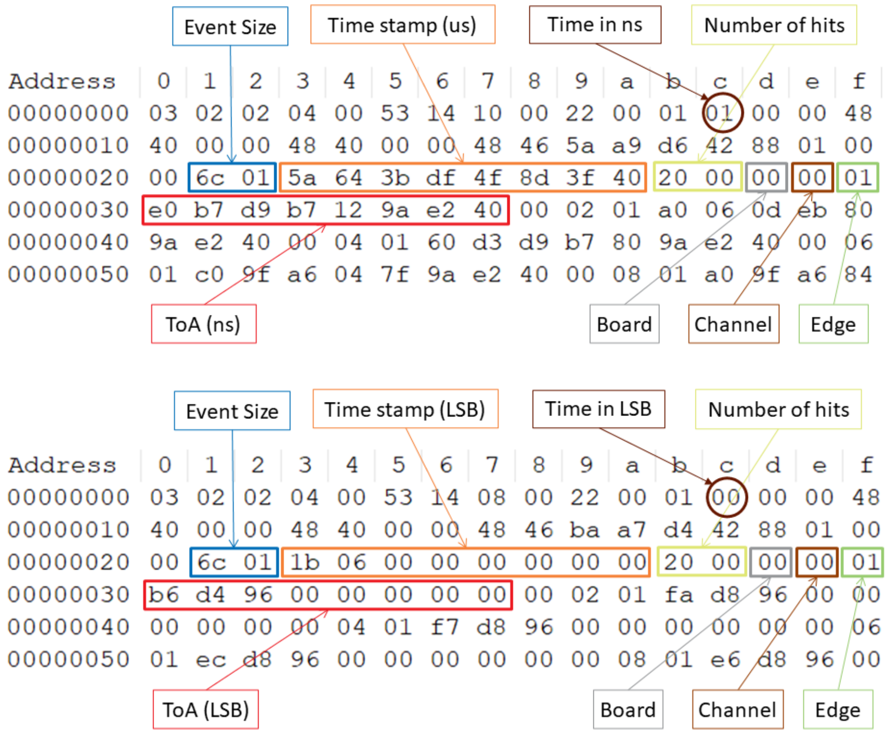


Fig. 3.31: Event List example in Streaming - LEAD_ONLY (binary format) in ns (*top*), and in LSB (*bottom*) time units.

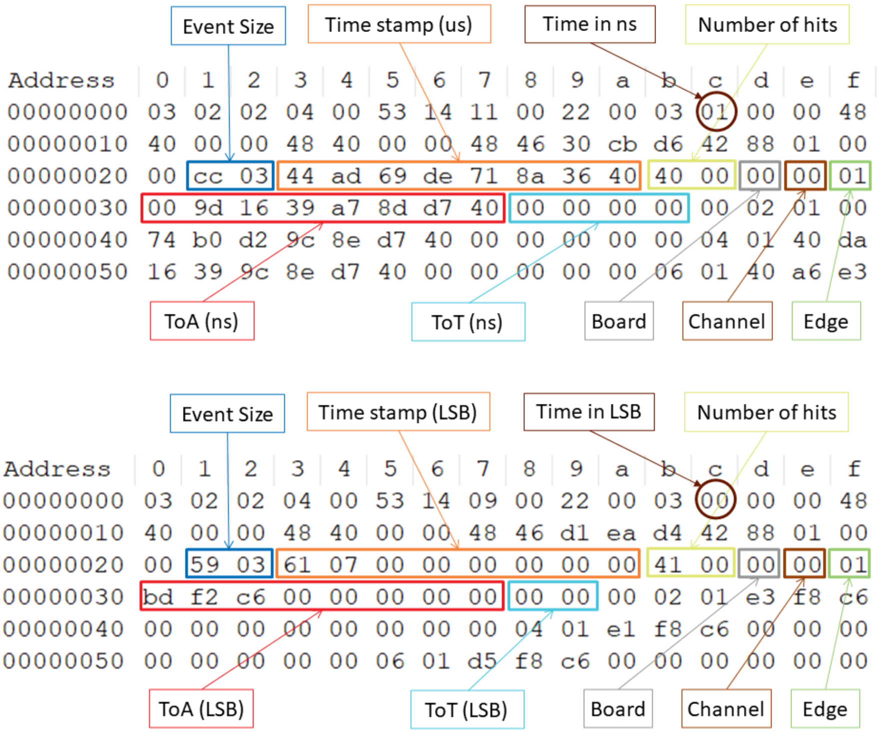


Fig. 3.32: Event List example in Streaming - LEAD_TRAIL (binary format) in ns (*top*), and in LSB (*bottom*) time units.

3.7.2 ASCII Format

In ASCII format, as for the binary format, each file is composed by a **header** with the information regarding the data format and software version, the acquisition mode, the measurement mode, time conversion, run number, and the time stamp of the start of the acquisition. The remaining information that is saved in the output file depends on the selected acquisition and measurement mode and is described below.

Common Start/Common Stop Mode

As for the correspondent binary file, the data part of the file contains the list of ToA (and ToT) values recorded for each enabled channel. Trigger time stamp in µs, Trigger ID, board and channel are reported as well for each event. An example of output files in Common Start Mode saved in ASCII format, afor all the possible Measurement Modes, is presented in **Fig. 3.33**, **3.34**, **3.35**, **3.36**, **3.37**, **3.38** for both ns and LSB time units.

```
//************************************************
// File Format Version 3.2
// Janus_5203 Release 2.4.0
// Acquisition Mode: Common Start
// Measurement Mode: Lead Only
// deltaT_LSB = 3.125 ps
// Run10 start time: Mon May 22 09:41:11 2023 UTC
//************************************************
     Tstamp_us        TrgID   Brd  Ch     deltaT_ns
       25.9968            0    00  00        67.359
                               00  02         3.875
                               00  04         3.872
                               00  06         3.816
                               00  08         3.803
                               00  10         3.809
                               00  12         3.747
                               00  14         3.781
                               00  16         3.731
```

Fig. 3.33: Event List example in Common Start Mode - LEAD_ONLY (ASCII format) in ns time units.

```
//************************************************
// File Format Version 3.2
// Janus_5203 Release 2.4.0
// Acquisition Mode: Common Start
// Measurement Mode: Lead Only
// deltaT_LSB = 3.125 ps; Tstamp_LSB = 12.8 ns
// Run1 start time: Fri May 19 09:48:01 2023 UTC
//************************************************
     Tstamp_LSB        TrgID   Brd  Ch     deltaT_LSB
           7955            0    00  00          21667
                                00  02           1102
                                00  04           1100
                                00  06           1087
                                00  08           1082
                                00  10           1084
                                00  12           1066
                                00  14           1076
                                00  16           1061
```

Fig. 3.34: Event List example in Common Start Mode - LEAD_ONLY (ASCII format) in LSB time units.

```
//************************************************
// File Format Version 3.2
// Janus_5203 Release 2.4.0
// Acquisition Mode: Common Start
// Measurement Mode: Lead Trail
// deltaT_LSB = 3.125 ps; ToT_LSB = 3.125 ps
// Run11 start time: Mon May 22 09:41:25 2023 UTC
//************************************************
     Tstamp_us        TrgID   Brd  Ch     deltaT_ns       ToT_ns
       32.7040            0    00  00        54.916        3.112
                               00  02         3.453       49.331
                               00  04         3.444       49.319
                               00  06         3.403       49.325
                               00  08         3.391       49.294
                               00  10         3.394       49.269
                               00  12         3.338       49.300
                               00  14         3.369       49.309
                               00  16         3.328       49.303
```

Fig. 3.35: Event List example in Common Start Mode - LEAD_TRAIL (ASCII format) in ns time units.

```
//**************************************************
// File Format Version 3.2
// Janus_5203 Release 2.4.0
// Acquisition Mode: Common Start
// Measurement Mode: Lead Trail
// deltaT_LSB = 3.125 ps; ToT_LSB = 3.125 ps; Tstamp_LSB = 12.8 ns
// Run2 start time: Fri May 19 09:48:14 2023 UTC
//**************************************************
      Tstamp_LSB        TrgID  Brd  Ch    deltaT_LSB      ToT_LSB
            5731            0   00  00         21471         1219
                                00  02          1344        15783
                                00  04          1341        15777
                                00  06          1329        15780
                                00  08          1326        15773
                                00  10          1328        15759
                                00  12          1303        15776
                                00  14          1319        15775
                                00  16          1298        15777
```

Fig. 3.36: Event List example in Common Start Mode - LEAD_TRAIL (ASCII format) in LSB time units.

```
//**************************************************
// File Format Version 3.2
// Janus_5203 Release 2.4.0
// Acquisition Mode: Common Start
// Measurement Mode: Lead TOT8
// deltaT_LSB = 3.125 ps; ToT_LSB = 50.000 ps
// Run20 start time: Mon May 22 11:39:05 2023 UTC
//**************************************************
       Tstamp_us         TrgID  Brd  Ch     deltaT_ns       ToT_ns
          8.5120             0   00  00        80.653        3.050
                                 00  02         3.500          OVF
                                 00  04         3.491          OVF
                                 00  06         3.444          OVF
                                 00  08         3.434          OVF
                                 00  10         3.444          OVF
                                 00  12         3.381          OVF
                                 00  14         3.416          OVF
                                 00  16         3.375          OVF
```

Fig. 3.37: Event List example in Common Start Mode - LEAD_TOT8-11 (ASCII format) in ns time units.

```
//**************************************************
// File Format Version 3.2
// Janus_5203 Release 2.4.0
// Acquisition Mode: Common Start
// Measurement Mode: Lead TOT8
// deltaT_LSB = 3.125 ps; ToT_LSB = 3.125 ps; Tstamp_LSB = 12.8 ns
// Run3 start time: Fri May 19 09:48:26 2023 UTC
//**************************************************
      Tstamp_LSB         TrgID  Brd  Ch    deltaT_LSB      ToT_LSB
            7105             0   00  00         21687          995
                                 00  02          1355          OVF
                                 00  04          1353          OVF
                                 00  06          1340          OVF
                                 00  08          1338          OVF
                                 00  10          1340          OVF
                                 00  12          1314          OVF
                                 00  14          1325          OVF
                                 00  16          1309          OVF
```

Fig. 3.38: Event List example in Common Start Mode - LEAD_TOT8-11 (ASCII format) in LSB time units.

Trigger Matching Mode

The output file contains, after the header, the list of enabled channels which input hits matched the trigger windows, together with the ToA and ToT values. **Fig. 3.39**, **3.40**, **3.41**, **3.42**, **3.43**, **3.44** are an example of ASCII event lists in ns and LSB time units for the possible different Measurement Modes.

```
//************************************************
// File Format Version 3.2
// Janus_5203 Release 2.4.0
// Acquisition Mode: Trigger Matching
// Measurement Mode: Lead Only
// ToA_LSB = 3.125 ps
// Run13 start time: Mon May 22 09:41:48 2023 UTC
//************************************************
     Tstamp_us        TrgID  Brd  Ch E       ToA_ns
       46.6944            0   00  00 L      950.681
                              00  02 L      954.472
                              00  04 L      954.466
                              00  06 L      954.425
                              00  08 L      954.419
                              00  10 L      954.422
                              00  12 L      954.341
                              00  14 L      954.372
                              00  16 L      954.328
```

Fig. 3.39: Event List example in Trigger Matching Mode - LEAD_ONLY (ASCII format) in ns time units.

```
//************************************************
// File Format Version 3.2
// Janus_5203 Release 2.4.0
// Acquisition Mode: Trigger Matching
// Measurement Mode: Lead Only
// ToA_LSB = 3.125 ps; Tstamp_LSB = 12.8 ns
// Run4 start time: Fri May 19 09:48:36 2023 UTC
//************************************************
    Tstamp_LSB         TrgID  Brd  Ch E      ToA_LSB
          7678             0   00  00 L       299792
                               00  02 L       301302
                               00  04 L       301301
                               00  06 L       301289
                               00  08 L       301284
                               00  10 L       301286
                               00  12 L       301267
                               00  14 L       301277
                               00  00 L       300201
```

Fig. 3.40: Event List example in Trigger Matching Mode - LEAD_ONLY (ASCII format) in LSB time units.

```
//************************************************
// File Format Version 3.2
// Janus_5203 Release 2.4.0
// Acquisition Mode: Trigger Matching
// Measurement Mode: Lead Trail
// ToA_LSB = 3.125 ps; ToT_LSB = 3.125 ps
// Run14 start time: Mon May 22 09:42:01 2023 UTC
//************************************************
     Tstamp_us        TrgID  Brd  Ch E       ToA_ns       ToT_ns
       44.6720            0   00  00 L      937.522            -
                              00  02 L      941.622            -
                              00  04 L      941.597            -
                              00  06 L      941.559            -
                              00  08 L      941.553            -
                              00  10 L      941.556            -
                              00  12 L      941.494            -
                              00  14 L      941.519            -
                              00  00 L      938.144            -
```

Fig. 3.41: Event List example in Trigger Matching Mode - LEAD_TRAIL (ASCII format) in ns time units.

```
//**************************************************
// File Format Version 3.2
// Janus_5203 Release 2.4.0
// Acquisition Mode: Trigger Matching
// Measurement Mode: Lead Trail
// ToA_LSB = 3.125 ps; ToT_LSB = 3.125 ps; Tstamp_LSB = 12.8 ns
// Run5 start time: Fri May 19 09:48:45 2023 UTC
//**************************************************
      Tstamp_LSB        TrgID   Brd  Ch E       ToA_LSB       ToT_LSB
            1232            0    00  00 L        299647             -
                                 00  02 L        301322             -
                                 00  04 L        301320             -
                                 00  06 L        301302             -
                                 00  08 L        301299             -
                                 00  10 L        301301             -
                                 00  12 L        301281             -
                                 00  14 L        301292             -
                                 00  00 L        299851             -
```

Fig. 3.42: Event List example in Trigger Matching Mode - LEAD_TRAIL (ASCII format) in LSB time units.

```
//**************************************************
// File Format Version 3.2
// Janus_5203 Release 2.4.0
// Acquisition Mode: Trigger Matching
// Measurement Mode: Lead TOT8
// ToA_LSB = 50.000 ps; ToT_LSB = 50.000 ps
// Run19 start time: Mon May 22 11:37:27 2023 UTC
//**************************************************
       Tstamp_us        TrgID   Brd  Ch E       ToA_ns        ToT_ns
          4.8640            0    00  00 L      937.400             -
                                 00  02 L      941.600        12.750
                                 00  04 L      941.600        12.750
                                 00  06 L      941.550        12.750
                                 00  08 L      941.550        12.750
                                 00  10 L      941.550        12.750
                                 00  12 L      941.500        12.750
                                 00  14 L      941.500        12.750
                                 00  00 L      938.200         3.000
```

Fig. 3.43: Event List example in Trigger Matching Mode - LEAD_TOT (ASCII format) in ns time units.

```
//**************************************************
// File Format Version 3.2
// Janus_5203 Release 2.4.0
// Acquisition Mode: Trigger Matching
// Measurement Mode: Lead TOT11
// ToA_LSB = 100.000 ps; ToT_LSB = 25.000 ps; Tstamp_LSB = 12.8 ns
// Run23 start time: Fri May 19 15:50:51 2023 UTC
//**************************************************
      Tstamp_LSB        TrgID   Brd  Ch E       ToA_LSB       ToT_LSB
              59            0    00  00 L          1318           122
                                 00  02 L          1353          1973
                                 00  04 L          1353          1972
                                 00  06 L          1352          1973
                                 00  08 L          1352          1972
                                 00  10 L          1352          1970
                                 00  12 L          1352          1972
                                 00  14 L          1352          1972
                                 00  16 L          1351          1973
```

Fig. 3.44: Event List example in Trigger Matching Mode - LEAD_TOT (ASCII format) in LSB time units.

Streaming Mode

The output file contains, after the header, the list of enabled channels, together with the input hits ToA and ToT values. **Fig. 3.45**, **3.46**, **3.47**, **3.48** are an example of ASCII event lists in ns and LSB time units for the possible different Measurement Modes.

```
//************************************************
// File Format Version 3.2
// Janus_5203 Release 2.4.0
// Acquisition Mode: Streaming
// Measurement Mode: Lead Only
// ToA_LSB = 3.125 ps
// Run16 start time: Mon May 22 09:42:24 2023 UTC
//************************************************
Brd  Ch E      ToA_ns
 00  00 L    38096.586
 00  02 L    38100.027
 00  04 L    38100.023
 00  06 L    38099.969
 00  08 L    38099.953
 00  10 L    38099.965
 00  12 L    38099.898
 00  14 L    38099.934
 00  16 L    38099.887
```

Fig. 3.45: Event List example in Streaming Mode - LEAD_ONLY (ASCII format) in ns time units.

```
//************************************************
// File Format Version 3.2
// Janus_5203 Release 2.4.0
// Acquisition Mode: Streaming
// Measurement Mode: Lead Only
// ToA_LSB = 3.125 ps; Tstamp_LSB = 12.8 ns
// Run8 start time: Mon May 22 09:40:12 2023 UTC
//************************************************
Brd  Ch E      ToA_LSB
 00  00 L      9884854
 00  02 L      9885946
 00  04 L      9885943
 00  06 L      9885932
 00  08 L      9885926
 00  10 L      9885930
 00  12 L      9885910
 00  14 L      9885920
 00  16 L      9885905
```

Fig. 3.46: Event List example in Streaming Mode - LEAD_ONLY (ASCII format) in LSB time units.

```
//*************************************************
// File Format Version 3.2
// Janus_5203 Release 2.4.0
// Acquisition Mode: Streaming
// Measurement Mode: Lead Trail
// ToA_LSB = 3.125 ps; ToT_LSB = 3.125 ps
// Run17 start time: Mon May 22 09:42:33 2023 UTC
//*************************************************
Brd  Ch E       ToA_ns       ToT_ns
 00  00 L    24118.613            -
 00  02 L    24122.451            -
 00  04 L    24122.441            -
 00  06 L    24122.391            -
 00  08 L    24122.373            -
 00  10 L    24122.385            -
 00  12 L    24122.318            -
 00  14 L    24122.354            -
 00  00 T    24122.078        3.466
```

Fig. 3.47: Event List example in Streaming Mode - LEAD_TRAIL (ASCII format) in ns time units.

```
//*************************************************
// File Format Version 3.2
// Janus_5203 Release 2.4.0
// Acquisition Mode: Streaming
// Measurement Mode: Lead Trail
// ToA_LSB = 3.125 ps; ToT_LSB = 3.125 ps; Tstamp_LSB = 12.8 ns
// Run9 start time: Mon May 22 09:40:30 2023 UTC
//*************************************************
Brd  Ch E      ToA_LSB      ToT_LSB
 00  00 L     13038269            -
 00  02 L     13039843            -
 00  04 L     13039841            -
 00  06 L     13039829            -
 00  08 L     13039825            -
 00  10 L     13039827            -
 00  12 L     13039808            -
 00  14 L     13039818            -
 00  00 L     13038733            -
```

Fig. 3.48: Event List example in Streaming Mode - LEAD_TRAIL (ASCII format) in LSB time units.

3.8 AcqMode Tab

The AcqMode Tab allows the user to set the value of all parameters concerning the different acquisition modes of the FERS-5200 unit, the trigger logic to be used as well as the settings of the front panel I/Os (see **Fig. 3.49**). Settings may differ according to the selected ”Acquisition Mode”.

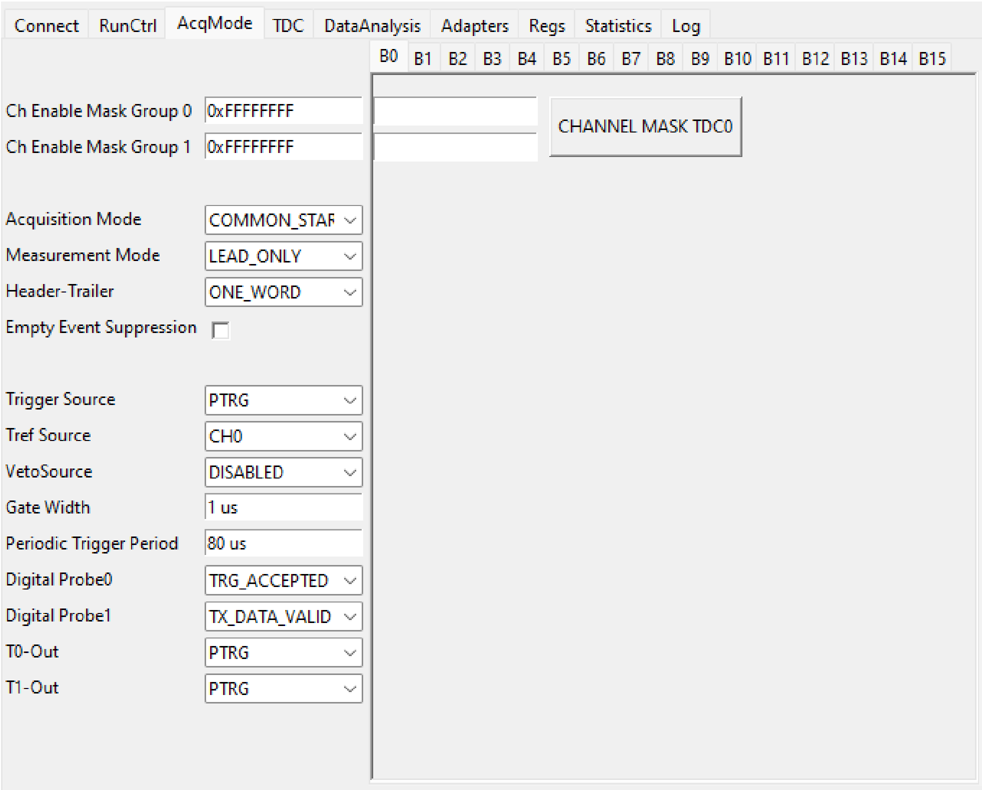


Fig. 3.49: Acquisition Mode Tab.

Ch Enable Mask Group 0

The command allows the user to enable/disable input channels from 0 to 31 of all boards connected. The default value (all channels enabled of all connected boards) is 0xFFFFFFFF.

Note: The input channel disabling means that that picoTDC channel does not record any hit.

Ch Enable Mask Group 1

The command allows the user to enable/disable input channels from 32 to 63 of all boards connected. The default value (all channels enabled of all connected boards) is 0xFFFFFFFF.

Note: The parameter values defined in the left part of the tab (in the fields near the parameter names) are applied to all connected boards (and all channels for some parameters) with no individual settings. In order to tune the values board-by-board and/or channel-by-channel, the user should act on the fields in the right part of the tab (see **Fig. 3.50**).

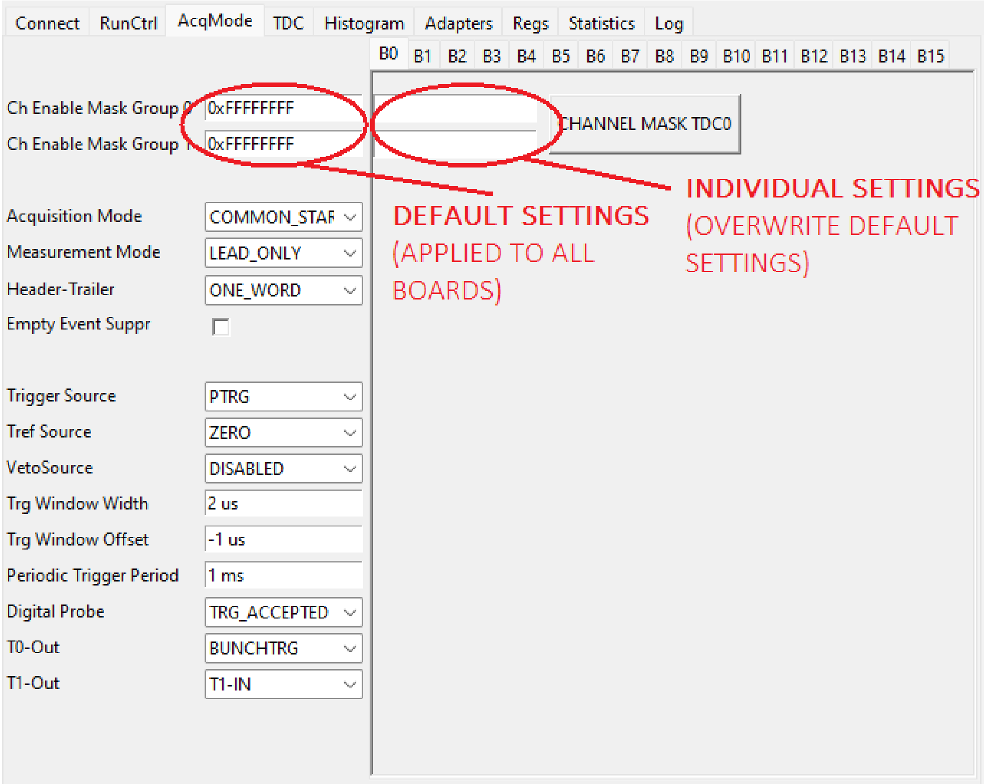


Fig. 3.50: The AcqMode Tab with underlined the two fields allowing the user to set the same Channel Mask for every board connected (fields on the left) or individually for each board (fields on the right).

CHANNEL MASK TDC0

By pressing the button, a Channel Mask window similar to that in **Fig. 3.52** will be opened. The user can then select which channels have to be enabled/disabled for the selected board. The user can switch between different boards (from 0 to 15) via the Board Tabs in the top right part of the AcqMode Tab (see **Fig. 3.51**) or via the Brd combo-box that is present in the Channel Mask window. Via this combo-box, the user can also define the default mask, i.e. the mask of all connected boards, by selecting the Global option. Once the selection is finished, the user should press the Done button in order to make the changes that have been made effective.

Note: The channel mask for the selected board overwrites the channel mask defined by the ”Ch Enable Mask Group 0” and ”Ch Enable Mask Group 1” parameters for all boards.

Fig. 3.51: Board Tabs.

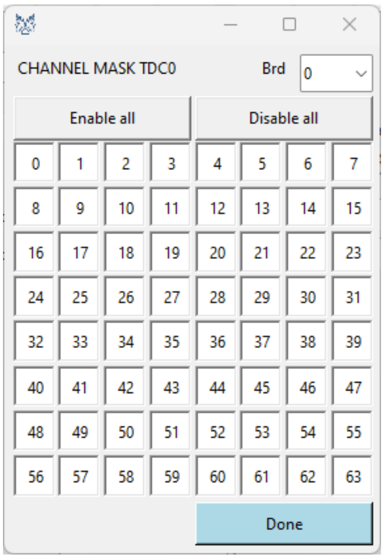


Fig. 3.52: Channel Mask window.

Acquisition Mode

The command allows the user to choose between the different acquisition modes. Possible values are:

- *COMMON_START*. The Common Start Mode is selected as acquisition mode.
- *COMMON_STOP*. The Common Stop Mode is selected as acquisition mode.
- *TRG_MATCHING*. The Trigger Matching Mode is selected as acquisition mode.
- *STREAMING*. The Streaming Mode is selected as acquisition mode.
- *TEST_MODE_1*. The Test Mode 1 is selected as acquisition mode. In this mode, the picoTDC is disabled and fake data are produced by the FPGA to emulate the readout process. One hit per channel is generated as to emulate the "COMMON_START" acquisition mode, with hard-coded time values, using ch 0 as a common start and the other channels from ch 1 to ch N (where N = 63 or 127) as common stops. If the set Gate width is shorter than the ch 0 - ch N time difference, the N^{th} channel may be discarded from the ΔT calculation. Disabled channels don't produce data. The rest of the readout logic behaves in the same way of the normal readout with real data from the picoTDC, including the memory management, the busy logic, the trigger rejection, etc...
- *TEST_MODE_2*. The Test Mode 2 is selected as acquisition mode. Same as TEST_MODE_1, but the FPGA produces 8 hits per channel instead of 1. The 8 hits of one channel have the same time value.

Note: The TEST_MODE acquisition modes are meant to be used for data readout tests, not for testing the picoTDC chip. The fake hits are generated at FPGA level, and their acquisition can be managed by the Janus 5203 software as if they were real events.

Measurement Mode

The command allows the user to choose between the different acquisition modes. Possible values are:

- *LEAD_ONLY*. The Leading Edge Mode is selected as measurement mode.
- *LEAD_TRAIL*. The Leading + Trailing Edge Mode is selected as measurement mode.
- *LEAD_TOT8*. The Leading Edge + ToT 8 bit Mode is selected as measurement mode.
- *LEAD_TOT11*. The Leading Edge + ToT 11 bit Mode is selected as measurement mode.

Header-Trailer

Events of 16 consecutive input channels, belonging to the same time acquisition window (gate or trigger window), are grouped together in one event packet. Information of the data acquisition, and of the board status are transferred, together with the event packet, in additional words. This parameter permits to define the number of words to be added to the data packet:

- KEEP_ALL: an Header and a Trailer added, respectively, before and after the 16ch-event packet (i.e. +2 words per event, meaning +8 words per 64ch-event packet, or +16 words per 128ch-event packet);
- ONE_WORD: a one word Trailer is added after the 64ch-event packet (i.e. +1 word per 64ch-event packet, +2 words per 128ch-event packet).

Empty Event Suppr

In Trigger Matching Acquisition Mode, this checkbox enables/disables the suppression of the empty events in the data throughput. The empty events are the events data packets in which no hit is present.

Trigger Source

The command defines the trigger source, i.e. the trigger transmitted to all channels and defining the start of the acquisition window.

The available options are:

- *SW_ONLY* [HEX 0x1]. The trigger is given only by software command.
- *T1-IN* [HEX 0x3]. The signal from the T1-IN connector is used as trigger source.
- *T0-IN* [HEX 0x11]. The signal from the T0-IN connector is used as trigger source.
- *PTRG* [HEX 0x21]. The internal periodic signal of the board is used as trigger source. The period of the signal is defined with the **Periodic Trigger Period** parameter.
- *EDGE_CONN* [HEX 0x41]. An external trigger signal fed via the A5255 or A5256 adapters (edge connector) is used as trigger source.
- *MASK*. The trigger signal is an ORed mask of the trigger sources listed above. The mask can be set by selecting the MASK option and writing the mask hexadecimal value next to the MASK option in the combo box, as shown in **Fig. 3.53**. In the example, the T1-IN and T0-IN options have been chosen as trigger source in OR-logic. The Trigger Source Register bits are defined as specified in **Tab. 3.1**.

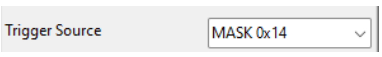


Fig. 3.53: Example of a Trigger Source Mask Setting.

Bit	Function
0	**SW_ONLY**. The trigger is given by software command.
1	**T1-IN_ONLY**. The signal on T1-IN is used as trigger.
3:2	**Reserved**.
4	**T0-IN_ONLY**. The signal on T0-IN is used as trigger.
5	**PTRG_ONLY**. The internal periodic signal of the board is used as trigger.
6	**EDGE_CONN_ONLY**. An external trigger signal fed via the A5255 or A5256 adapters (edge connector) is used as trigger source.
7	**EDGE_CONN_PB_ONLY**. An external trigger signal fed via the piggyback edge connector (only in case of A5203B units) is used as trigger source.

Tab. 3.1: Trigger Source Register description.

Note: The **Trigger Source** parameter applies to Common Start, Common Stop and Trigger Matching Acquisition Modes.

Tref Source

The command defines the signal to be used as time reference (T_{ref}), see **[RD1]**. In Janus 5203, the picoTDC ch0 channel (that does not correspond to the ch0 channel of the edge connector) is used as T_{ref}. The picoTDC ch0 channel can have different drivers. The available options are:

- *CH0*. The reference signal comes from the input 0 (ch0) of the edge connector.
- *T1-IN*. The signal from the T1-IN connector is used as time reference, and drives the ch0 channel of the picoTDC chip. No signal must drive the ch0 channel of the edge connector.
- *T0-IN*. The signal from the T0-IN connector is used as time reference, and drives the ch0 channel of the picoTDC chip. No signal must drive the ch0 channel of the edge connector.
- *PTRG*. The internal periodic signal of the board is used as time reference, and drives the ch0channel of the picoTDC chip. No signal must drive the ch0 channel of the edge connector.

Veto Source

This parameter allows the user to define the signal source that, as far as it is in an high logic level, inhibits all trigger signals. The available options are:

- *DISABLED*. The Veto is disabled.
- *T0-IN*. The signal transmitted to the T0-IN connector is used as veto.
- *T1-IN*. The signal transmitted to the T1-IN connector is used as veto.
- *MASK*. The Veto signal is an ORed mask of the Veto signals listed. The mask can be set by selecting the MASK option and writing the mask hexadecimal value next to the MASK option in the combo box, as shown in the Trigger Source Mask example of **Fig. 3.53**.
  The Veto Source Register bits are defined as specified in **Tab. 3.2**

Bit	Function
0	**SW_CMD**. The veto is given by software command.
1	**T0-IN**. The signal on T0-IN is used to veto the acquisition.
2	**T1-IN**. The signal on T1-IN is used to veto the acquisition.

Tab. 3.2: Veto Source Register description.

Gate/Trigger Window Width

The command defines the duration of the Gate/Trigger Window, in steps of $\sim$25.6 ns.

Note: The **Gate Width** parameter is used in Common Start/Stop Acquisition Mode. The **Trigger Window Width** parameter is used in Trigger Matching Acquisition Mode.

Trigger Window Offset

The command defines the start of the Trigger Window with respect to the trigger position. It is defined in steps of $\sim$25.6 ns, and can be positive or negative. Negative offsets might be useful to acquire hits that are too close to the trigger and could be lost.

Note: It is possible to set the Trigger Window Offset when working in Trigger Matching Mode only.

Periodic Trigger Period

The command defines the period of the internal periodic pulser of the board. The signal can be used as periodic trigger in order to force triggers not related to the physics (for debugging). The value for this parameter can be set between 64 ns and $\approx$ 54 s.

Digital Probe 0/1

The command defines which digital signal has to be propagated to one of the two digital output connectors T0-OUT/T1-OUT. More information on the digital probe signals can be found in the A5203(B)/DT5203 User Manual **[RD1]**. The available options are:

- *CLK_1024*. FPGA clock divided by 1024.
- *TRG_ACCEPTED*. Accepted trigger signal.
- *TRG_REJECTED*. Rejected trigger signal (i.e. the triggers that arrive when the board is in busy status).
- *TX_DATA_VALID*. A signal of one clock cycle width ($\sim$12.8 ns) is sent to the T0-OUT/T1-OUT when a word is sent to the communication link.
- *TX_PCK_COMMIT*. A signal of one clock cycle width ($\sim$12.8 ns) is sent to the T0-OUT/T1-OUT when a data packet is ready to be transmitted from the List Output FIFO to the communication link.
- *TX_PCK_ACCEPTED*. A signal of one clock cycle width ($\sim$12.8 ns) is sent to the T0-OUT/T1-OUT when the communication link (TDlink, Ethernet or USB) is ready to receive and transmit a data packet.
- *TX_PCK_REJECTED*. A signal of one clock cycle width ($\sim$12.8 ns) is sent to the T0-OUT/T1-OUT when the communication link (TDlink, Ethernet or USB) is not ready to receive and transmit a data packet.
- *TDC_DATA_VALID*. A signal of one clock cycle width ($\sim$12.8 ns) is sent to the T0-OUT/T1-OUT when a data packet has been transferred from the TDC Readout Buffer to the List Output FIFO.
- *TDC_DATA_COMMIT*. A signal of one clock cycle width ($\sim$12.8 ns) is sent to the T0-OUT/T1-OUT when a data packet is ready to be written on the List Output FIFO.

T0-OUT

The command defines the digital signal driving the T0-OUT connector. The available options are:

- *T0-IN*. The signal sent as input to the T0-IN connector is propagated to the T0-OUT connector (after having being resynched by the FPGA).
- *TRIGGER*. The trigger signal, both accepted and rejected, selected with the **Trigger Source** parameter.
- *RUN*. The Run signal (high logic level when the acquisition is ongoing).
- *PTRG*. The internal periodic signal of the board.
- *BUSY*. The Busy signal.
- *DPROBE*. The Digital Probe is propagated to the T0-OUT connector. The signal associated to the digital probe is defined by the **Digital Probe 0/1** parameter.
- *SQ_WAVE*. A square wave having the same period of the internal periodic pulser of the board.
- *TDL_SYNC*. Signal of synchronism from TDLink. The user can visualize the TDL_SYNC from multiple boards to check that they are all latched together.
- *RUN_SYNC*. Signal of start run from TDLink. The user can visualize the RUN_SYNC from multiple boards to check that the starts run are all latched together.
- *ZERO*. A constant low logic level is sent as output. To be used when performing a daisy chained trigger distribution in a multi-board system (refer to the A5203(B)/DT5203 User Manual **[RD1]**).
- *MASK*.The T0-OUT signal is an ORed mask of the T0-OUT signals listed. The mask can be set by selecting the MASK option and writing the mask hexadecimal value next to the MASK option in the combo box, as shown in the Trigger Source Mask example of **Fig. 3.53**.
  The T0-OUT Register bits are defined as specified in **Tab. 3.3**

Bit	Function
0	**T0_IN**. The signal sent as input to the T0-IN connector.
1	**TRIGGER**. The trigger signal.
2	**Reserved**.
3	**RUN**. The RUN signal.
4	**PTRG**. The internal periodic signal of the board.
5	**BUSY**. The BUSY signal.
6	**DPROBE**. The DPROBE signal defined by the **Digital Probe 0/1** parameter.
7	**Reserved**.
8	**SQ_WAVE**. A square wave having the same period of the internal periodic pulser of the board.
9	**TDL_SYNC**. The TDL_SYNC signal, sent via the TDLink when connected to the DT5215.
10	**RUN_SYNC**. The RUN_SYNC signal, sent via the TDLink when connected to the DT5215.
11	**Reserved**.

Tab. 3.3: T0-OUT Register description.

T1-OUT

The command defines the digital signal driving the T1-OUT connector. The available options are:

- *T1-IN*. The signal sent in input to the T1-IN connector is propagated to the T1-OUT connector.
- *TRG*. See **T0-OUT**.
- *RUN*. See **T0-OUT**.
- *PTRG*. See **T0-OUT**.
- *BUSY*. See **T0-OUT**.
- *DPROBE*. See **T0-OUT**.
- *SQ_WAVE*. See **T0-OUT**.
- *TDL_SYNC*. See **T0-OUT**.
- *RUN_SYNC*. See **T0-OUT**.
- *ZERO*. See **T0-OUT**.
- *MASK*. See **T0-OUT**.

3.9 TDC Tab

The TDC Tab allows the user to configure the picoTDC chip (see **Fig. 3.49**), in case the default configuration is not fitting the customer needs.

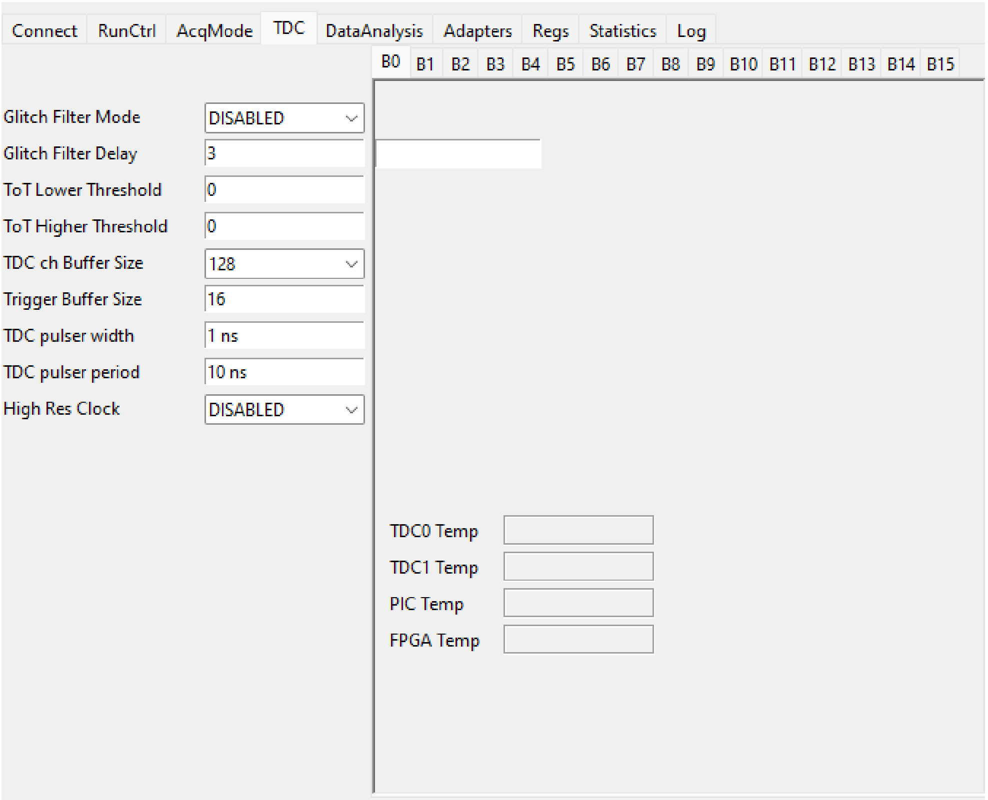


Fig. 3.54: TDC Tab.

Glitch Filter Mode

The command defines the picoTDC Glitch Filter Mode. The Glitch Filter is a programmable pulse filter that can be assigned to the picoTDC channels. It can filter leading and/or trailing edges to enforce the minimum time between hits and/or reject possible oscillations from the analog front-end.
The available options are:

- *DISABLED*. The glitch filter is disabled.
- *TRAILING*. The glitch filter is used only on the trailing edge of the hits.
- *LEADING*. The glitch filter is used only on the leading edge of the hits.
- *BOTH*. The glitch filter is used on both leading and trailing edges of the hits.

Glitch Filter Delay

This command allows the user to set the Glitch Filter Delay, i.e. the artificial dead time introduced to avoid glitches and afterpulses (see **Glitch Filter Mode**), from a minimum value of ∼800 ps to a maximum value of ∼10 ns (in 16 steps of ∼570 ps). It is possible to set a different Glitch Filter Delay for each board in the setup.

ToT Lower Threshold

This command allows the user to filter data from the picoTDC as a function of their ToT value, by setting a lower threshold. Hits with ToT smaller than the set value are rejected. If 0 is written as lower threshold, the filter is disabled.

ToT Higher Threshold

This command allows the user to filter data from the picoTDC as a function of their ToT value, by setting a higher threshold. Hits with ToT bigger than the set value are rejected. If 0 is written as higher threshold, the filter is disabled.

Note: The **ToT Lower Threshold** and **ToT Higher Threshold** parameters are not available if working in LEAD_ONLY and LEAD_TRAIL Measurement Modes.

TDCch Buffer Size

The command allows the user to select the internal picoTDC chip individual channels buffer size (refer to **[RD4]** for more details). The maximum number of hits accepted in the buffer is:

- *4*
- *8*
- *16*
- *32*
- *64*
- *128 (default)*
- *256*
- *512*

The proper setting of the TDC channel buffer size is needed to avoid the hits overflow on the picoTDC Readout Buffer, that has a default size of 512. The overflow may happen more commonly in case of noise on the enabled picoTDC channels.

Note: The excess hits in the TDC channel buffer are rejected by the picoTDC chip, and thus not counted by the FPGA.

Trigger Buffer Size

This command allows the user to set the size of the FPGA Trigger FIFO (TRGF), in the range 1-512 number of triggers (default = 16). The overflowing trigger are rejected by the FPGA, but counted.
The proper setting of the Trigger Buffer Size is needed to avoid events loss in the List Output FIFO (LSOF). Refer to Sec. **3.13** and to the A5203(B)/DT5203 User Manual **[RD1]** for more details.

TDC pulser width

The picoTDC contains a pulse generator for system testing purposes, able to generate a differential output signal. The output can either be a 1.28 GHz clock with selectable phase shift or a configurable pulse. This command allows the user to set the picoTDC chip pulser width (in ns). The width can range from a minimum of 1 ns to a maximum of 256 µs.

TDC pulser period

This command allows the user to set the period (in ns) of the picoTDC chip pulser (see the description given for the **TDC pulser width** parameter). The width can range from a minimum of 1 ns to a maximum of 256 µs.

High Res Clock

The command allows the user to configure the High Resolution Clock settings. The available options are:

- *DISABLED*.
- *DAISY_CHAIN*. The CLK-IN and CLK-OUT connectors are connected in daisy-chain
- *FAN_OUT*. The CLK-IN and CLK-OUT connectors are connected in fan-out mode.

The TDC Tab houses a board monitoring section, shown in **Fig. 3.55**.

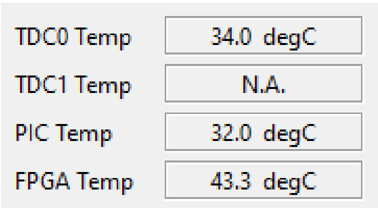


Fig. 3.55: Monitoring section of the TDC Tab.

This section shows the TDC0 (and TDC1, in case of 128 channels), the PIC microcontroller, and the FPGA temperatures. When the FPGA or TDC0/1 maximum allowed temperature is reached (83 °C), a WARNING pop-up is generated by the Janus 5203 software. If the TDC0/1 is the chip that has reached the maximum temperature, it is powered off.

3.10 DataAnalysis Tab

The DataAnalysis Tab allows the user to manage the histograms settings and to enable/configure the ToA Walk Correction. Settings may differ according to the Measurement Mode selected.
In case of LEAD_ONLY Measurement Mode, the DataAnalysis Tab appears as shown in **Fig. 3.56**.

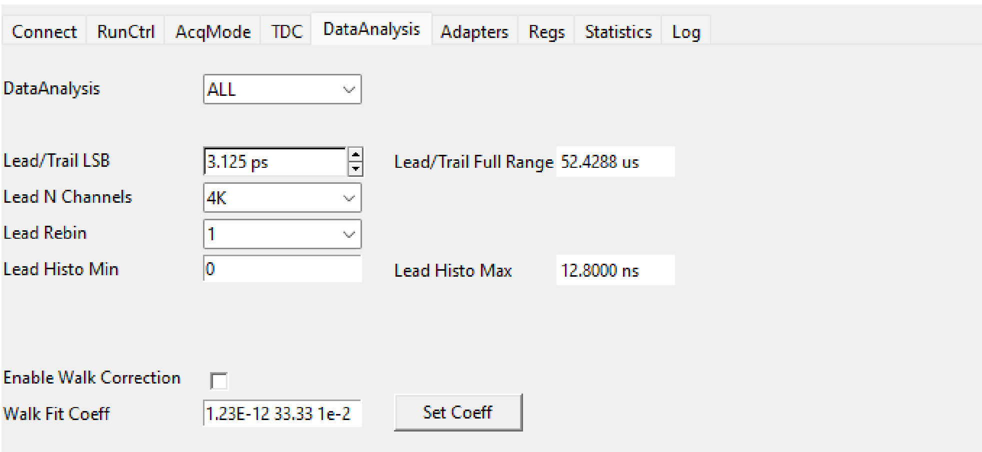


Fig. 3.56: DataAnalysis Tab in case of LEAD_ONLY acquisition.

In case of LEAD_TRAIL, LEAD_TOT8 and LEAD_TOT11 Measurement Modes, the DataAnalysis Tab appears as shown in **Fig. 3.57**.

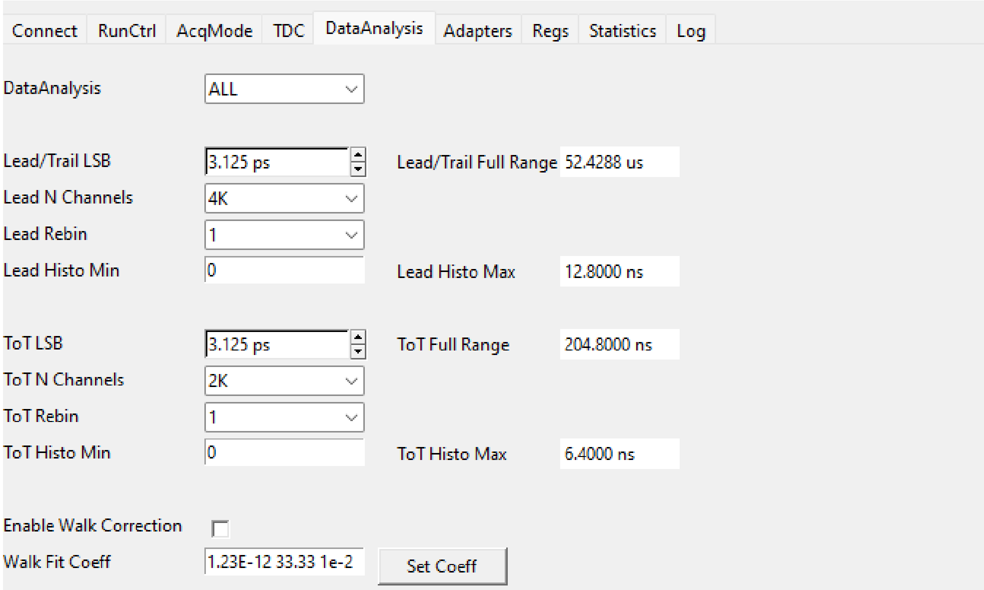


Fig. 3.57: DataAnalysis Tab in case of LEAD_TRAIL, LEAD_TOT8 and LEAD_TOT11 acquisition.

Lead/Trail LSB

This parameter permits to choose the ToA LSB for the leading edge (and trailing edge, only in LEAD_TRAIL Measurement Mode) of the hits. The LSB value is written over 11 bits, and the minimum LSB value is 3.125 ps. The ToA LSB, thus, can be:

- 3.125 ps
- 6.25 ps
- 12.5 ps
- 25.0 ps
- 50.0 ps
- 100.0 ps
- 200.0 ps
- 400.0 ps
- 800.0 ps
- 1.6 ns
- 3.2 ns

In case of LEAD_TOT8 Measurement Mode, the maximum ToA LSB allowed value is 400 ps.
In case of LEAD_TOT11 Measurement Mode, the maximum ToA LSB allowed value is 3.2 ns.

Lead/Trail Full Range

This box shows the ToA Full Range. Given the minimum ToA LSB of 3.125 ps, and a 24/26 bit dynamic (that depends on the Header-Trailer mode chosen via the **Header-Trailer** parameter), the Full Range is fixed at 52.429/209.715 µs in case of LEAD_ONLY and LEAD_TRAIL Measurement modes.
In case of LEAD_TOT8 Measurement Mode, the ToA presents a dynamic of 17/19 bits. The Lead ToA can then range from a minimum of 409.600 ns/1.638 µs to a maximum of 52.429/209.715 µs, depending on the selected LSB. In case of LEAD_TOT11 Measurement Mode, the ToA presents a dynamic of 14/16 bits, but, with the advantage of using bigger LSB values, the minimum and maximum dynamic ranges are the same available for the LEAD_TOT8 Measurement Mode.

Lead N Channels

This parameter is used to set the number of bins of the Spect Lead/Trail histogram, or disable the histogram filling. The available options are:

- DISABLED
- 256
- 512
- 1K
- 2K
- 4K
- 8K
- 16K

Note: The disabling of the historam filling diables also the histogram data writing on the Histo file.

Lead Rebin

This parameters permits to rebin the Spect Lead/Trail histogram. The rebinning factor can be:

- 1
- 2
- 4
- 8
- 16
- 32
- 64

Lead Histo Min

This parameter shows the minimum Spect Lead histogram value (0 LSB/ns by default), and permits the user to set a value different from 0.

Lead Histo Max

This parameters shows the maximum range of the Spect Lead histogram.

ToT LSB

This parameter permits to choose the ToT LSB of the hits. The LSB value is written over 19 bits, and the minimum LSB value is 3.125 ps. The ToT LSB value, thus, can be:

- 3.125 ps
- 6.25 ps
- 12.5 ps
- 25.0 ps
- 50.0 ps
- 100.0 ps
- 200.0 ps
- 400.0 ps

- 800.0 ps
- 1.6 ns
- 3.2 ns
- 6.4 ns
- 12.8 ns
- 25.6 ns
- 51.2 ns
- 102.4 ns
- 204.8 ns
- 409.6 ns
- 819.2 ns

In case of LEAD_TOT8 Measurement Mode, the maximum ToT LSB allowed value is 819.2 ns.
In case of LEAD_TOT11 Measurement Mode, the maximum ToT LSB allowed value is 102.4 ns.

ToT Full Range

This box shows the ToT Full Range. In LEAD_TRAIL Measurement mode, the ToT is calculated by the Janus 5203 software, and it is written over 16 bits. The LEAD_TRAIL ToT can then range from a minimum of 204.800 ns to a maximum of 52.429 µs, depending on the selected LSB. Even if the LSB can be selected, the time measurement is performed with the maximum resolution of 3.125 ps.
In case of LEAD_TOT8 Measurement Mode, the ToT presents a dynamic of 8 bits. The ToT can then range from a minimum of 800.000 ps to a maximum of 209.715 µs, depending on the selected LSB. In case of LEAD_TOT11 Measurement Mode, the ToT presents a dynamic of 11 bit, but, with the advantage of using smaller LSB values, the minimum and maximum dynamic ranges are the same available for the LEAD_TOT8 Measurement Mode.

ToT N Channels

This parameter is used to set the number of bins of the Spect ToT histogram, or disable the histogram filling. The available options are:

- DISABLED
- 256
- 512
- 1K
- 2K
- 4K
- 8K
- 16K

Note: The disabling of the historam filling diables also the histogram data writing on the Histo file.

ToT Rebin

This parameters permits to rebin the Spect ToT histogram. The rebinning factor can be:

- 1
- 2

- 4
- 8
- 16
- 32
- 64

ToT Histo Min

This parameter shows the minimum Spect ToT histogram value (0 LSB/ns by default), and permits the user to set a value different from 0.

ToT Histo Max

This parameters shows the maximum range of the Spect ToT histogram.

Enable Walk Correction

The checkbox enables/disables the Walk Correction.

Walk Fit Coeff

The ToA Walk can be corrected thanks to a polynomial fit, based on the ToT-amplitude relation, which estimated curve coefficients can be set by pressing the Set Coeff button. The window of **Fig. 3.58** appears. The combo box permits to select the function used for the fit. The C_0, C_1, C_2, C_3, C_4, C_5 fields are used to set the fit coefficients. The coefficients are set once pressed the "DONE" button.

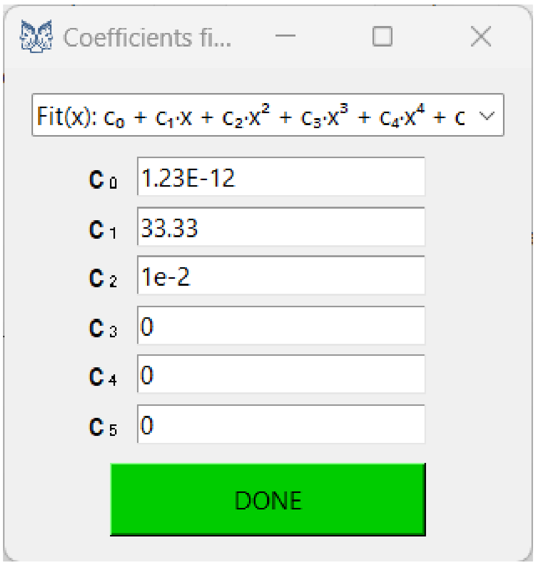


Fig. 3.58: Set Walk Correction Coefficient pop-up window.

3.11 Adapters Tab

The Adapters Tab, shown in **Fig. 3.59** allows the user to select and configure the adapter mounted on the unit. Starting from Rev.1 of the A5256, the individual channel signal polarity is set via jumpers on the adapter, except for channel 0, for which the polarity can be selected through the **A5256 Ch0 Polarity** parameter.

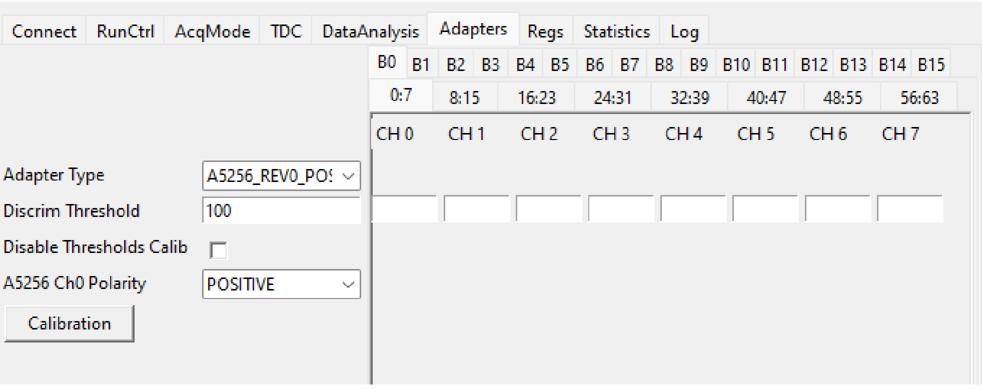


Fig. 3.59: Adapters Tab.

For the A5256 adapter **[RD5]**, the discriminator threshold can be set for all the adapter's channels, or for the single channel.
On the upper right part of the Tab, it is possible to select the board and the channel group, as shown in **Fig. 3.60**.

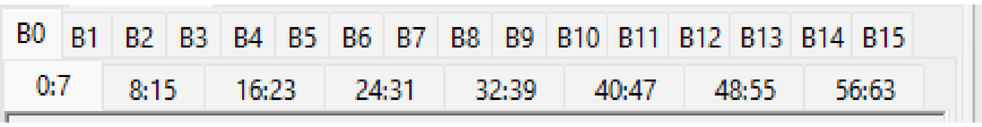


Fig. 3.60: Adapters Tab board/channel group Tabs.

The discriminator threshold value set for the single channel overwrites the value set for the whole board, for that specific channel.
The calibration for the discriminators threshold can be performed by clicking on the *Calibration* button. The calibration can be performed with no cables plugged on the LEMO 00 connectors, or with the cables plugged, as to take into account the common ground of the experimental setup.
After the calibration is performed, the values obtained are stored in the flash memory of the A5203/DT5203 and, subsequently, used to correct the discriminators threshold offset. It is possible to disable the correction by checking the box **Disable Threshold Calib**.

Note: The threshold values measured on the test points of the A5256 **[RD5]** are not calibrated.

3.12 Regs Tab

In order to properly manage the registers access, the Janus 5203 GUI also features the Regs Tab (see **Fig. 3.61**).

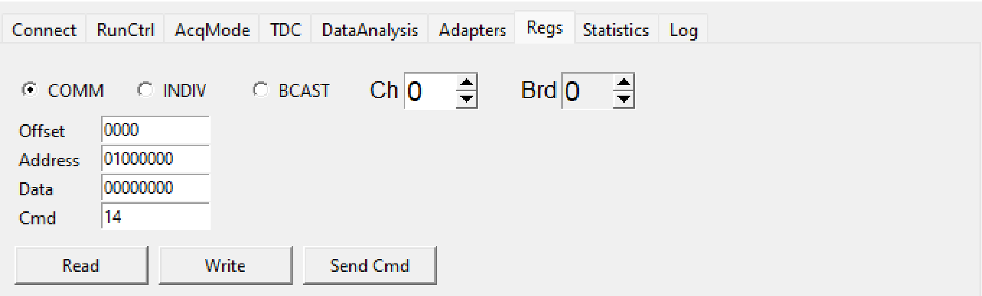


Fig. 3.61: The Regs Tab of the Janus 5203 software GUI.

The user can take advantage of the "macros" file to add a list of register settings in the Janus 5203 configuration. Refer to Sec. **3.1** (par. **File**) for additional details.

3.13 Statistics Tab

The Statistics Tab displays the channel-by-channel values of the variable selected via the **Statistics Type** combo-box, as well as the last event triggered time stamp, the trigger ID, the lost triggers, etc. (see **Fig. 3.62** and **Fig. 3.63**).

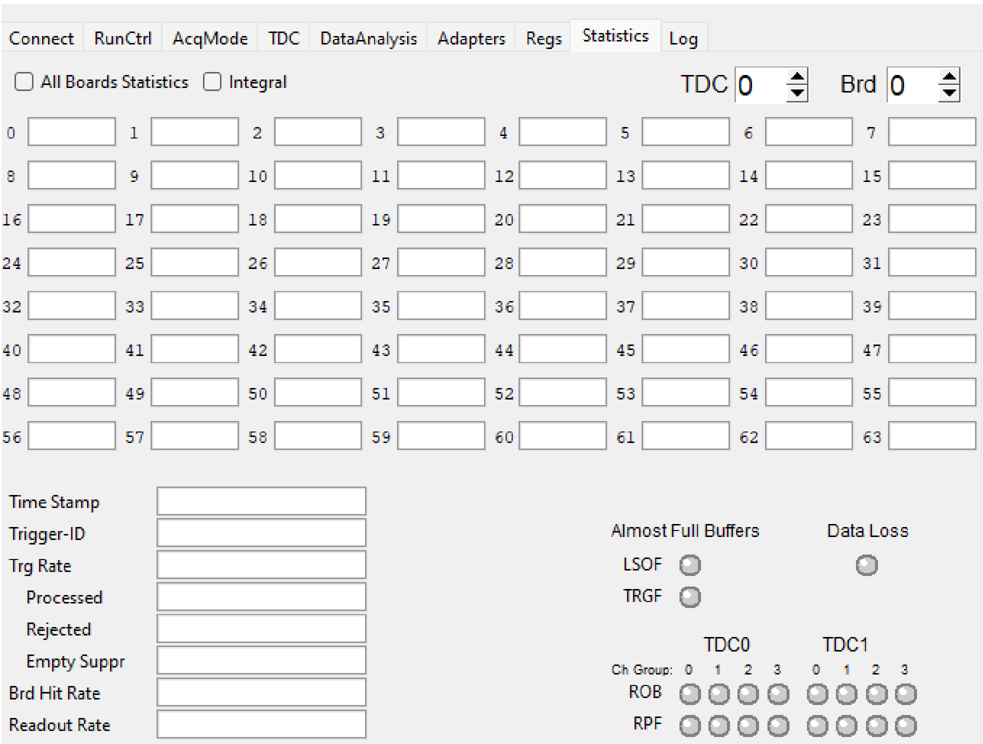


Fig. 3.62: Statistics Tab for COMMON_START, COMMON_STOP, TRG_MATCHING and TEST_MODE Acquisition Modes.

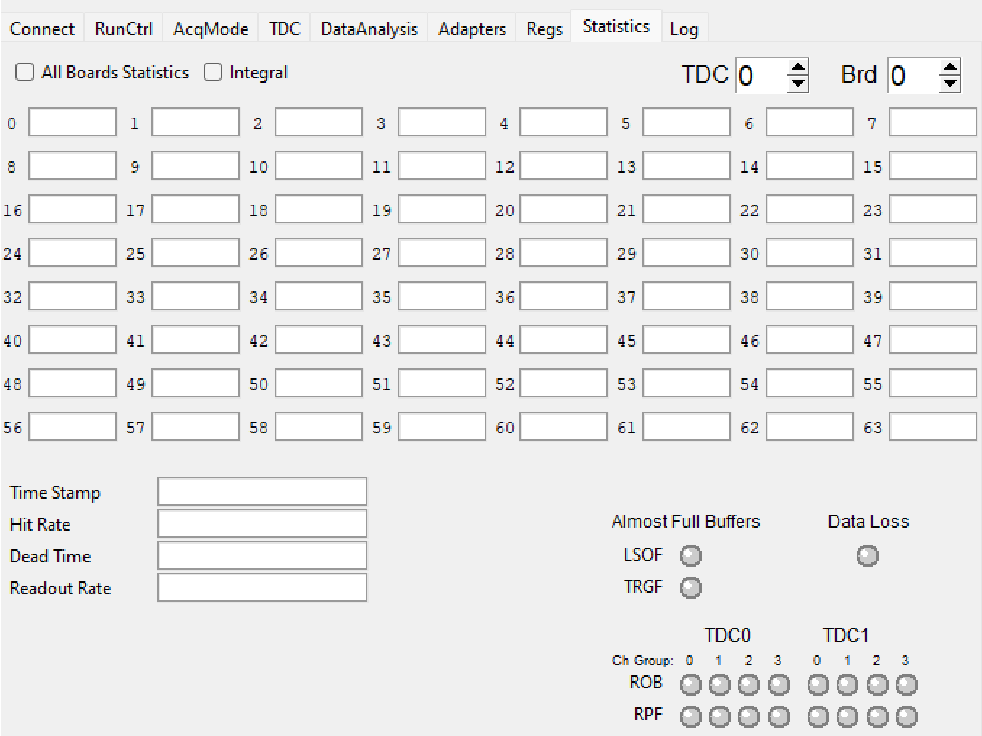


Fig. 3.63: Statistics Tab forthe STREAMING Acquisition Mode.

The user can select the board from the **Brd** switch on the top right part of the Statistics tab, to visualize the channel statistics of one of the connected boards.

The checkbox **Integral** allows the user to show the statistics in Instantaneous (unchecked box) or Integral (checked box) mode.

The values displayed in the table are (depending on the Acquisition Mode selected):

- **N**: Where N is the channel number (from 0 to 63). The user can choose via the **Statistics Type** command which value has to be displayed (see Sec. **3.3**).
- **Time Stamp**: The time stamp of the latest event read out.
- **Trigger-ID**: The ID number of the latest read-out event is displayed.
- **Trg Rate/Hit Rate**: The trigger rate of the acquisition, or the hit rate in case of STREAMING Acquisition Mode.
- **Processed**: The rate (in cps) and the percentage of the triggers processed by Janus 5203. Data in the readout pipeline are not considered for this rate.
- **Rejected**: The percentage and total number of triggers rejected by the FPGA. This information allows the user to visualize the number of triggers that were counted but not acquired because of the board busy condition.
- **Empty Suppr**: The percentage of events suppressed because fulfilling the empty condition. See **Empty Event Suppr** parameter in the Acquisition Tab.
- **Board Hit Rate**: The rate of the totality of the hits in all the enabled channels.
- **Readout Rate**: The data readout rate.

On the bottom right part of the Statistics Tab, detailed information about the Board Almost Full Condition are reported:

- **LSOF**: The List Output FIFO (internal to the FPGA) is in an Almost Full condition, and the board enters in a BUSY condition.

- **TRGF**: The Trigger FIFO (internal to the FPGA) is in an Almost Full condition, and the board enters in a BUSY condition. The Trigger FIFO buffer size size is hardcoded at a value smaller than the Trigger Buffer size.
- **Data Loss**: The LSOF is Full, and the FPGA starts to reject hit data to prevent FIFO overrun. Headers and trailers of the events are kept to guarantee data consistency.
- **TDCx-ROBF (x=0,1)**: The Readout Port FIFO of channel group n (with n=0,...,3) is in an Almost Full condition, and the board enters in a BUSY condition. Each Ch Group is composed by 16 channels, and there are four Readout Port FIFOs (internal to the FPGA) per each TDC chip.
- **TDCx-RPF (x=0,1)**: The TDC Readout Buffer of channel group n (with n=0,...,3) is in an Almost Full condition, and the board enters in a BUSY condition. Each Ch Group is composed by 16 channels, and there are four Readout Buffers (internal to the TDC chip) per each TDC chip.

Note: TDC1 buffers Almost Full condition information are valid only when working with the A5203B board type, that present a further picoTDC chip (and thus further 64 channels) mounted on the piggyback.

Note: The Data Loss parameter indicates data loss caused by an LSOF full condition, but this is not the only condition causing data loss. Other data losses are possible and described in Sec. 9.3.1 of **[RD1]**.

The individual channel buffer (internal to the TDC chip) Almost Full condition is reported by the individual channel statistics box colored in yellow. This condition implies hits rejections performed by the picoTDC chip.
Refer to the A5203(B)/DT5203 User Manual **[RD1]** and to the picoTDC Datasheet **[RD2]** for further details on the A5203(B)/DT5203 Almost Full condition.

By clicking on the **All Boards Statistics** button, the Statistics Tab will look like that presented in **Fig. 3.64**. This option allows the user to visualize the statistics described above (except those regarding the rejected trigger as well as the board hit rate) for all connected boards in the same screen.

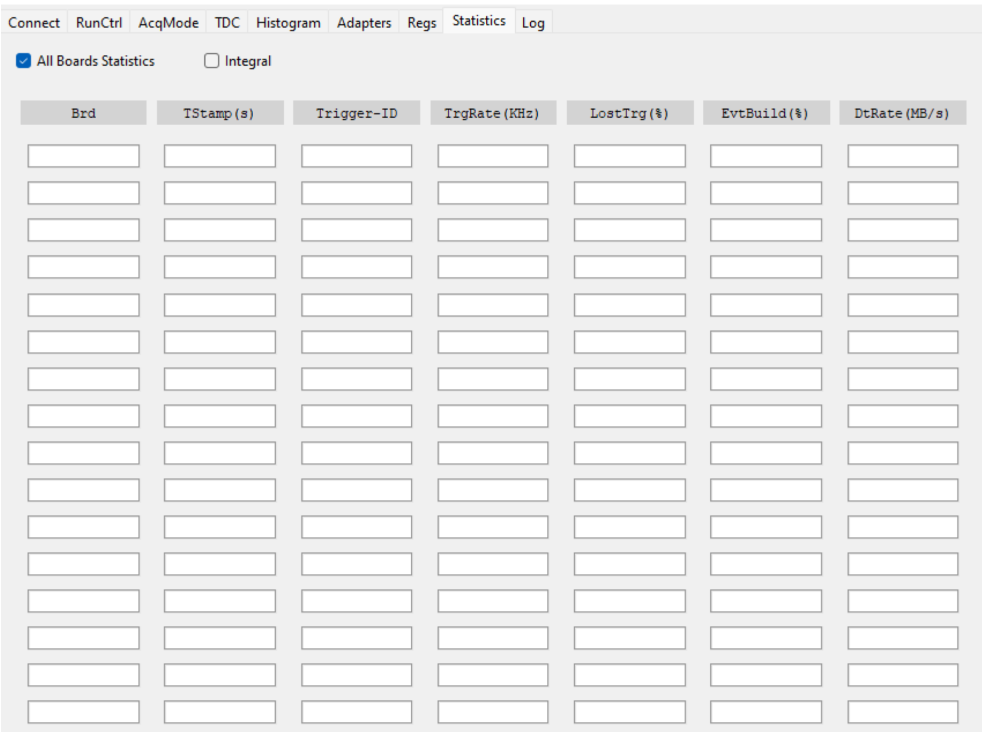


Fig. 3.64: Statistics Tab with the "All Boards Statistics" option selected.

3.14 Log Tab

The Log Tab contains information about the sequence of operations performed by Janus 5203, such as board configuration, status monitor, board information, etc. (see **Fig. 3.65**). If an error occurs when loading the configuration file (e.g. because of a syntax error), a warning message is displayed in this tab.
All the messages visualized in the Log Tab are also saved in the ”MsgLog.txt” file inside the ”bin” folder of the Janus 5203 software.

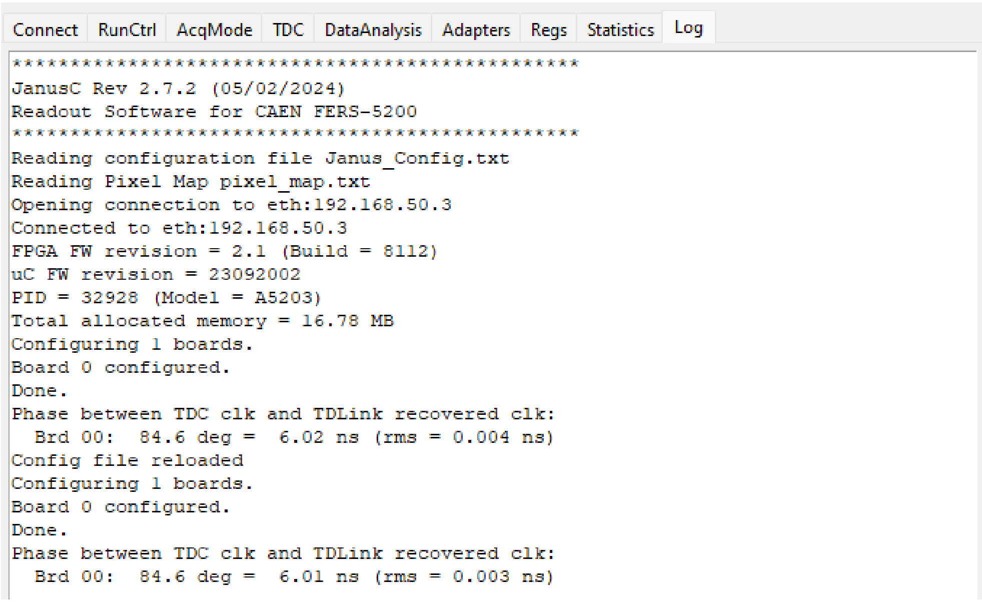


Fig. 3.65: Log Tab.

3.15 How to Perform a Job

The aim of this section is to provide the user with a brief introduction on how to perform a job with Janus 5203. A job is a series of consecutive runs, i.e. acquisitions, with programmable time length or with programmable number of events. The number of runs composing each job is also programmable. There are two ways to perform a job in Janus 5203:

1. With the same configuration of parameters for each run, defined inside the "Janus_Config.txt" file. This case is suitable if the user needs to perform several acquisitions changing, e.g., the intensity of the light pulse directed to the SiPMs from one run to the other, but acquiring data with the same DAQ settings.
2. With a different configuration of parameters for each run. The set of parameter values for the run X of the job are defined inside a configuration file named "Janus_config_RunX.txt" created by the user via the **Save Run Configuration Button**. This case is suitable if the user needs to perform several acquisitions by changing the settings of one crucial parameter for each run, e.g. the **Lead/Trail LSB** value.

The instructions for both ways of operating are described below:

1. Select the RunCtrl Tab and put a thick in the **Enable Jobs** parameter.
2. Select the "ASYNC" option for the **Start Run Mode** parameter. For the **Stop Run Mode**, the user has to select:
   - "PRESET_TIME", if the user would like to perform runs of the same duration.
   - "PRESET_COUNTS", if the user would like to perform runs having the same number of events.
3. Select a value for the **Preset Time** parameter different from 0 (e.g. 1 m for a one-minute acquisition) if the "PRESET_TIME" option was chosen for the **Stop Run Mode** parameter. Select a value for the **Preset Counts** parameter different from 0 (e.g. 1000 for an acquisition of a thousand events) if the "PRESET_COUNTS" option was chosen for the **Stop Run Mode** parameter.
4. Select the ID number of the first run in the job via the **Job First Run** parameter (e.g. 1) and for the last run in the job via the **Job Last Run** parameter (e.g. 5).
5. Select a value for the **Run Sleep** parameter (e.g. 10 s), which determines the time distance between the end of a run and the start of the next one.
6. Select one or more options for the output files to be saved for each run (e.g. "List (ASCII)").
7. Select via the **Run#** parameter in the Command Bar a value identical to the ID of the first run in the job, i.e. the value chosen for the **Job First Run** parameter (in this case 1).
8. Press the Apply button. The JanusC.exe application will suddenly close and restart (in about 5 s) without any further action to be performed by the user. At the end of this operation, the **Start Button** will be replaced by the **Start Job Button**.
9. In **Fig. 3.66** the settings chosen to perform a job acquisition are presented.
10. If all runs have to be executed according to the configuration of parameters actually saved, the user has to push the **Start Job Button**. The user can check the status of the job in the Status Bar (see Sec. **3.4**) and the data files creation in the destination folder.
11. If a different configuration of parameters is needed for each run, the user has to:
    (a) Press the **Save Run Configuration Button**. The user can check that in the "bin/DataFiles" folder a configuration file named "Janus_config_RunX.txt" has been created, being X the value of the **Run#** parameter (in this case 1).
    (b) Select the values of the parameters for the second run in the job. Once finished, press the Apply button.
    (c) Select via the **Run#** parameter a value identical to the ID of the second run in the job (in this case 2).

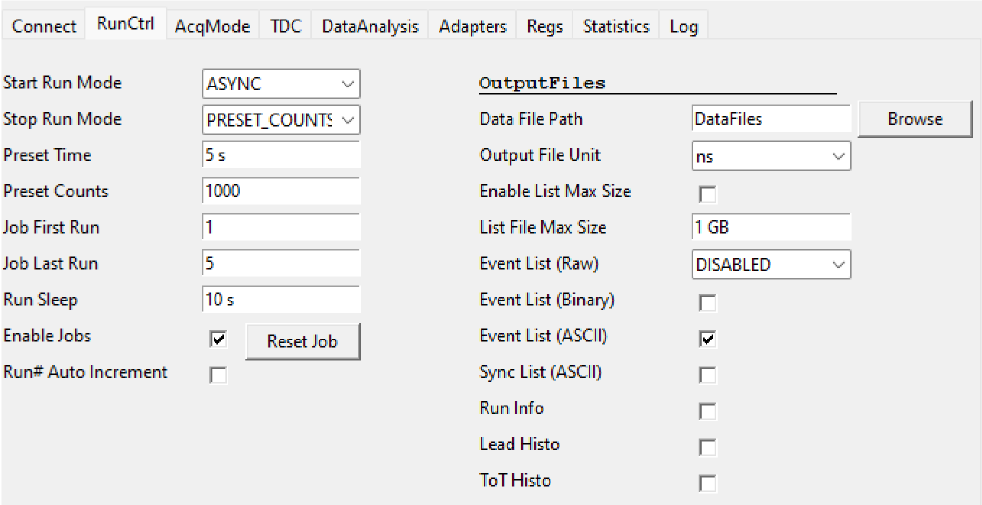


Fig. 3.66: Example of settings for a job acquisition.

(d) Press the **Save Run Configuration Button**. Another configuration file is suddenly created in the ”bin/DataFiles” folder named ”Janus_config_RunY.txt”, being Y the **Run#** parameter value for the second run in the job.

(e) The user has to repeat the instructions above as many times as the number of runs composing the job.

(f) Press the **Start Job Button**. The user can check the status of the job in the Status Bar (see Sec. **3.4**) and that the data files are created in the destination folder.

4 Console Mode

In this operative mode, the user can edit the configuration file (”Janus_Config.txt” in the ”bin” folder) with any text editor and save the proper values for the desired parameters (see Chap. **3** for details regarding the complete list of available parameters). Then the user can launch ”JanusC.exe”, which starts in a purely textual console window (see **Fig. 4.2**).

Note: If using Windows 11 with Windows Terminal as default shell, please consider to modify the shell settings as shown in **Fig. 4.1** to get the expected behavior of JanusC console mode.

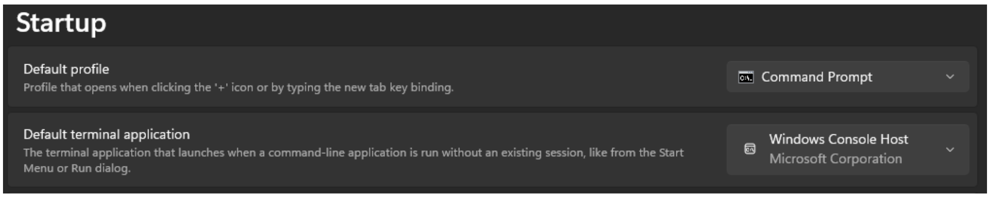


Fig. 4.1: Windows 11 shell settings for JanusC console mode.

Note: In Console Mode, the user can modify the ”Janus_Config.txt” file also by accessing the parameter values in the ”JanusPy.pyw” application without pressing the Connect button. In this case, the Janus 5203 GUI is simply used as a configuration panel and every time the Apply button is pressed the configuration file is overwritten.

```
*************************************************
JanusC Rev 2.7.2 (05/02/2024)
Readout Software for CAEN FERS-5200
*************************************************
Reading configuration file Janus_Config.txt
Reading Pixel Map pixel_map.txt
Opening connection to eth:192.168.50.3
Connected to eth:192.168.50.3
FPGA FW revision = 2.1 (Build = 8112)
uC FW revision = 23092002
PID = 32928 (Model = A5203)
Num of connected boards = 1
Total allocated memory = 16.78 MB
Configuring 1 boards.
Board 0 configured.
Done.
Phase between TDC clk and TDLink recovered clk:
  Brd 00:  84.7 deg =  6.02 ns (rms = 0.002 ns)
Ready to start Run #1 (1 of 5, Preset = 1000 cnts)
Press [s] to start, [q] to quit, [SPACE] to enter the menu
```

Fig. 4.2: Starting window of the Janus 5203 software when operating in Console Mode.

Once started, the ”JanusC.exe” application parses the configuration file. If a formal error occurs, it is displayed in the console window. Possible not valid parameter values or syntax errors in the configuration file are indicated by the software by displaying a warning message. After having established the connection with the board, Janus 5203 programs it with the parameters read. Finally, by pressing the command ”s”, the acquisition is started.

During the acquisition loop, a special menu (bindkeys) allows the user to send commands to the program by previously selecting the ”JanusC.exe” console window.
The list of all console commands is presented in Sec. **4.2**.

4.1 Configuration File Syntax

This section describes the structure of the Janus 5203 configuration file (”Janus_Config.txt”) and the syntax of all the defined parameters. The parameters are the same described in Chap. **3** and the user should refer to that chapter in order to have more detailed information about their functions.
The Janus 5203 configuration file is divided in three main parts:

- **Connection Settings**, indicated in the initial ”Connect” section of the file.
- **Common Settings**, indicated in the initial ”Common and Default settings” section of the file. The value of these parameters is applied to all channels of all connected boards.
- **Individual Settings**, indicated in the section ”Board and Channel settings”. The value of these parameters is applied individually to specific connected boards and/or to specific channels.

The individual settings can be performed also in the common settings part: in this case, they are applied to all channels of all connected boards.

Note: Settings are executed sequentially, therefore commands written at the end of the file (in the part of the individual settings) may overwrite settings written at the beginning (in the part of the common settings).

4.1.1 Connection Settings

This part of the configuration file allows the user to define the type of connection of the boards. An example is shown in **Fig. 4.3**. The ”Open” word is followed by the ID number of the board between square brackets (by default the ID number is 0 if only one board needs to be connected). The user has then to specify the type of connection.

```
# ------------------------------------------------------------------------------------------
# Connect
# ------------------------------------------------------------------------------------------
Open[0] eth:192.168.50.3
```

Fig. 4.3: Example of connection settings in the ”Janus_Config.txt” file.

4.1.2 Common Settings

This part of the configuration file allows the user to define all the settings that have to be applied to all channels of all boards connected. This part of the file is organized as the different tabs in the Janus 5203 GUI. An example is shown in **Fig. 4.4**.

Note: The parameter names can be different to that in the Janus 5203 GUI. Indeed, the parameter names appearing in the Janus 5203 GUI are defined in the ”param_rename.txt” file inside the ”bin” folder.

```
# ------------------------------------------------------------------------------------------
# AcqMode
# ------------------------------------------------------------------------------------------
ChEnableMask0                     0xFFFFFFFF          # Channel enable mask TDC0 (ch 0..31)
ChEnableMask1                     0xFFFFFFFF          # Channel enable mask TDC0 (ch 32..63)
ChEnableMask2                     0xFFFFFFFF          # Channel enable mask TDC1 (ch 64..95)
ChEnableMask3                     0xFFFFFFFF          # Channel enable mask TDC1 (ch 96..127)
AcquisitionMode                   COMMON_START        # Acquisition mode. Options: COMMON_START, COMMON_STOP, TRG_MATCHING,
STREAMING, TEST_MODE_1, TEST_MODE_2
MeasMode                          LEAD_ONLY           # Time measurement mode. Options: LEAD_ONLY, LEAD_TRAIL, LEAD_TOT8,
LEAD_TOT11
En_Head_Trail                     ONE_WORD            # Enable Header and Trailer. Options: KEEP_ALL, ONE_WORD
En_Empty_Ev_Suppr                 0                   # Enable empty event suppression
TriggerSource                     PTRG                # Trigger source. Options: SW_ONLY, T1-IN, T0-IN, PTRG, EDGE_CONN, MASK
TrefSource                        CH0                 # Time reference source. Options: CH0, T0-IN, T1-IN, PTRG
VetoSource                        DISABLED            # The veto signal inhibits the trigger source (active high). Options:
DISABLED, T0-IN, T1-IN, MASK
GateWidth                         1 us                # Gate Width (will be rounded to steps of 12.8 ns)
TrgWindowWidth                    2 us                # Trigger Window Width (will be rounded to steps of 12.8 ns)
TrgWindowOffset                   -1 us               # Trigger Window Offset = start of the trg window respect to trigger
                                                      position (can be negative, will be rounded to steps of 12.8 ns)
PtrgPeriod                        1 ms                # Period of the internal periodic trigger
DigitalProbe0                     TRG_ACCEPTED        # Digital probe source (T0-OUT). Options: CLK_1024, TRG_ACCEPTED,
                                                      TRG_REJECTED, TX_DATA_VALID, TX_PCK_COMMIT, TX_PCK_ACCEPTED,
                                                      TX_PCK_REJECTED, TDC_DATA_VALID, TDC_DATA_COMMIT
DigitalProbe1                     TX_DATA_VALID       # Digital probe source (T1-OUT). Options: CLK_1024, TRG_ACCEPTED,
                                                      TRG_REJECTED, TX_DATA_VALID, TX_PCK_COMMIT, TX_PCK_ACCEPTED,
                                                      TX_PCK_REJECTED, TDC_DATA_VALID, TDC_DATA_COMMIT
T0_Out                            TRIGGER             # T0_Out assignment. Options: T0-IN, TRIGGER, RUN, PTRG, BUSY, DPROBE,
                                                      SQ_WAVE, TDL_SYNC, RUN_SYNC, ZERO, MASK
T1_Out                            T1-IN               # T1_Out assignment. Options: T1-IN, TRIGGER, RUN, PTRG, BUSY, DPROBE,
                                                      SQ_WAVE, TDL_SYNC, RUN_SYNC, ZERO, MASK
```

Fig. 4.4: Example of common settings in the ”Janus_Config.txt” file.

4.1.3 Individual Settings

This part of the configuration file allows the user to define all the settings that have to be applied to a particular board and/or to a particular channel. The user has to write down the parameter name followed by the board number in square brackets ([0] if only one board is connected) and by the channel number in square brackets. An example is shown in **Fig. 4.5**.

```
# ***************************************************************************************
# Board and Channel settings (overwrite default settings)
# ***************************************************************************************
DiscrThreshold[0][1]            35          #
```

Fig. 4.5: Example of individual setting for the 1st channel of the board 0 adapter in the ”Janus_Config.txt” file.

If the parameter can differ only board-by-board, but not channel-by-channel, the parameter has to be written in the same part of the configuration file. In this case, the parameter has to be written down followed only by the board number in square brackets. An example is presented in **Fig. 4.6**.

```
# ***************************************************************************************
# Board and Channel settings (overwrite default settings)
# ***************************************************************************************
GlitchFilterDelay[2]            2           #
```

Fig. 4.6: Example of individual board setting in the ”Janus_Config.txt” file.

4.2 Console Commands

Key	Function
Space Bar	**Print Command Menu**. Print on screen the list of all console commands.

q	**Quit**. Exit from the Janus 5203 software.
s	**Start acquisition**.
S	**Stop acquisition**.
t	**SW Trigger**. This command sends a software trigger (single shot), useful especially when the card has no data (no trigger) because it forces the acquisition of an event.
C	**Set stats monitor type**. Allows the user to change between the different statistics printed on the Janus 5203 console window during the acquisition. The available options (the same reported in Sec. **3.3** for the ”Statistics Type” parameter) are: • **0**. Hit Rate: The channels hits rate matching the reference trigger is displayed. • **1**. Hit Cnt: The channels hits count matching the reference trigger is displayed. • **2**. Tot Rate: The channel read hits rate is displayed. • **3**. Tot Cnt: The channel read hits count is displayed. • **4**. Lead Mean: Estimated mean value of the Lead ToA. • **5**. Lead RMS: Estimated RMS value of the Lead ToA. • **6**. ToT Mean: Estimated mean value of the ToT (not working for LEAD_ONLY Measurement Modes) • **7**. ToT RMS: Estimated RMS value of the ToT (not working for LEAD_ONLY Measurement Modes) • **[Other keys]**. Return.
[tab]	**Change statistics channel/board**. The command allows the user to change between channel and board statistics printed on the screen.
i	**Change statistics mode (integral/updating)**. The command allows the user to change between integral and updating statistics printed on the screen.
P	**Set plot mode**. Janus 5203 has several plot modes that can be activated one at a time. More information about the different plots can be found in Sec. **3.3**. The available options are the following: • **0**. Spect Lead: Leading edge Time of Arrival (ToA) spectrum (X-axis = ToA, Y-axis = Counts). • **1**. Spect Trail: Trailing edge Time of Arrival (ToA) spectrum (X-axis =ToA, Y-axis = Counts). • **2**. Spect ToT: Time over Threshold spectrum (X-axis = ToT, Y-axis = Counts). • **3**. Counts: Histogram of the total number of counts per second per channel (X-axis = Channel number from 0 to 63, Y-axis = Counts per Second). • **[Other keys]**. Return.
x	**Enable/Disable x-axis calibration**.the ToA and ToT spectra can have the x-axis scale expressed in Channels or in a calibrated quantity (ns). This key toggles between the two modes. **NOTE**: The spectra plots also display the mean and RMS values, expressed in channels or in the calibrated quantity depending on the option chosen.
b	**Change board**. This command allows the user to change between active boards (since by default the board 0 is the active one) when more than one board is connected at the same time.
c	**Change channel**. During the acquisition, only one channel is enabled in the plots in Console Mode. With this key, the channel enabled in the plots is changed. It is possible to scroll through the channels by pressing ’+’ (next channel) and ’-’ (previous channel).
f	**Freeze plot**. During the acquisition run, the plot is automatically updated (approximately once per second). However, it is possible to stop the histogram update (while the acquisition continues) to observe the one-shot plot by pressing this command. Pressing again the command re-enables the automatic histogram update.
o	**One shot plot**. Force a plot update when the ”Freeze plot” is enabled.
r	**Reset histograms**. The command resets the content of all histograms and the values of the statistics.

j	**Reset jobs (when enabled)**. This command allows the user to interrupt the entire job (if enabled) and start over.
!	**Reset IP address**. This command resets the IP address of the board to 192.168.50.3. **NOTE**: This command can be used only when connected to the board via USB.
U	**Upgrade firmware**. The command allows the user to upgrade the FPGA firmware of a particular connected board.
T	**Calibrate discriminator thresholds**. The command allows the user to calibrate the thresholds of the A5256 discriminators, and save the calibration file in the board flash memory.
m	**Register manual controller**. The command opens a sub-menu which allows the user to directly access the board registers (manual controller). The available commands in the sub-menu are: • **b**. Change base (0100). • **c**. Change channel (00). • **+**. Next channel. • **-**. Prev channel. • **a**. Set address (01000000). • **r**. Read reg (00000000). • **w**. Write reg (00000000). • **s**. Send command (00). • **i**. I2C R/W reg. • **R**. Read flash page. • **W**. Write flash page. • **q**. Return.

Tab. 4.1: Janus 5203 console commands.

5 Plot Window and Commands

Plots in the Janus 5203 software are managed by *gnuplot*, which is an external plot engine. The plot data are written to a support file, then, via pipe, a series of commands are sent to gnuplot which displays the requested plot. The commands include setting the dimensions, titles, X and Y axis labels, plot type, colours, etc.
When working in GUI Mode, the user can select different traces at the same time to appear in the gnuplot window thanks to the Plot Traces window (see **Fig. 3.6**). In particular, in the top right part of the gnuplot window a legend is displayed (see **Fig. 5.1**).

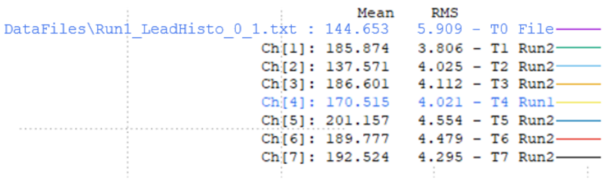


Fig. 5.1: Traces legend in the gnuplot window.

The information reported there are:

- **Channel ID**, displayed as CH[Board ID][Channel ID]. The [Board ID] is shown when using multiple boards only. It is not present in case of single board usage.
- **Mean**, Mean value of the selected spectrum for the particular channel. The units for that value are those displayed in the x axis and selected via the "Calib X-axis" command in the Plot Traces window (see **Fig. 3.6**).
- **RMS**, The RMS value of the selected spectrum for the particular channel. The units for that value are those displayed in the x axis.
- **Trace ID**, displayed as TN, being N the Trace ID.
- **Run ID**, displayed as RunN, being N the Run ID.

In case of an Offline run, the relative line on the legend is written in Ocean Blue color.

Gnuplot has some predefined "bindkeys"; other bindkeys are set (depending on the type of plot) by Janus 5203 via the command pipe. A bindkey is activated by pressing a key when the gnuplot window is active. In **Tab. 5.1** the main bindkeys for gnuplot (valid for most of the plots) are listed.

Key	Function
a	**X & Y Autoscale**. Performs the autoscale of both X and Y axis.
x	**X Autoscale**. Performs the X axis autoscale.
y	**Y Autoscale**. Performs the Y axis autoscale.
g	**Grid**. Set a grid along the X and Y axis.
r	**Enable/Disable Ruler**. Enable or disable the ruler. In the bottom part of the window, the X and Y coordinates of the starting position of the cursor are displayed, together with the value of ΔX and ΔY of the new cursor position with respect to the starting position.
Right Click + Move + Left Click	**Zoom**. Performs a zoom in a region of the plot. To perform a zoom the user has to right click with the mouse (e.g. on the top left-hand corner), release the right mouse button, move the cursor (e.g. to the bottom right-hand corner) and then left click.
p	**Previous Zoom**. Return to the previous zoom.

u	**Un-Zoom**. Return to the initial zoom status.
l	**Enable/Disable Y Log Scale**. The command allows the user to enable or disable the logarithmic scale on the Y axis.
L	**Enable/Disable X or Y Log Scale**. The command allows the user to enable or disable the logarithmic scale on the axis closer to the cursor.

Tab. 5.1: Gnuplot window commands.

The gnuplot window also features an Icon Bar (see **Fig. 5.2**).

Fig. 5.2: Icon Bar of the gnuplot window.

The available commands (part of them can be performed also via the previously described bindkeys) are:

- Copy the plot to the clipboard .
- Save the plot in various formats .
- Refresh the plot .
- Display the grid .
- Return to the previous zoom .
- Apply the next zoom settings .
- Apply the autoscale .
- Open a *gnuplot* configuration window similar to that in **Fig. 5.3** .
- Open an help dialog window .

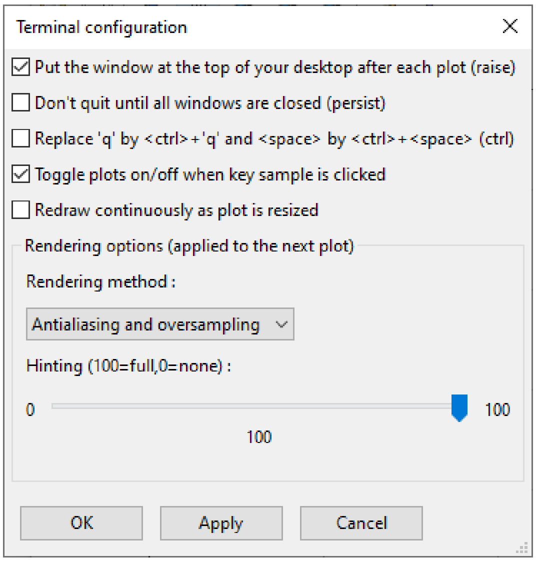


Fig. 5.3: Gnuplot configuration window.

6 DebugLog Mask

Janus 5203 provides a default log file for each data acquisition run. The log file (Msg_log.txt) can contain a greater or lesser amount of information depending on the verbosity enabling/disabling in the GUI mode menu (see Sec. **3.1**). The information saved in the log file are the same that are displayed in the Janus 5203 GUI Log Tab (Sec. **3.14**), or console, during a run. If more information are needed, it is possible to enable/disable bits of the DebugLog Mask via a macro (see Sec.**3.1**). The macro should contain:
`DebugLogMask value`
where `value` is an hexadecimal number, that can be:

- `0x1` - a FERSlib_log.txt file is created. The file contains the FERS library log. It is updated only if an error happens during the data acquisition.
- `0x2` - a RawEvents.txt file is created. A dump of the data, already divided per events, is saved on the file.
- `0x4` - a ll_log_x.txt file is created, where x is the board number. A dump of the raw data arriving from each board, with no processing performed, is saved on the file.
- `0x8` - a ll_log_x.txt file is created, where x is the board number (information added to the same file created for the 0x4 log). The start and stop of the run information, for each board, are saved on the file.
- `0x10` - a queue_log.txt file is created. This log is used just in the case of data building enabled, and it prints to the file the que of each event.
- `0x20` - a RawDecodeLog_x.txt file is created, where x is the board number. The board payload and other information are saved on the file.
- `0x40` - a ll_readdata_log_x.txt file is created, where x is the board number. Same information given by the 0x4 settings, with the only difference that the data are dumped after having passed by the memory buffer of the board.

7 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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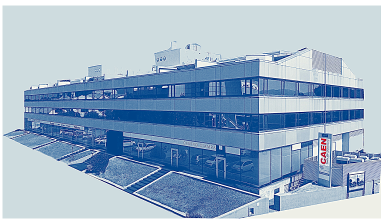
www.caen-india.in



UM9636 - Janus 5203 - CAEN A5203(B)/DT5203 Readout Software rev. 0 - February 7th, 2024 00103/19:XJ5203.MUTX/00

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