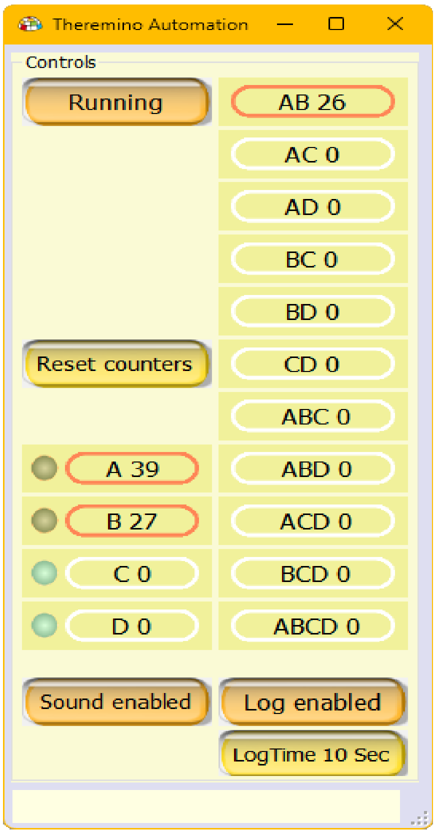
theremino

•the•real•modular•in-out•

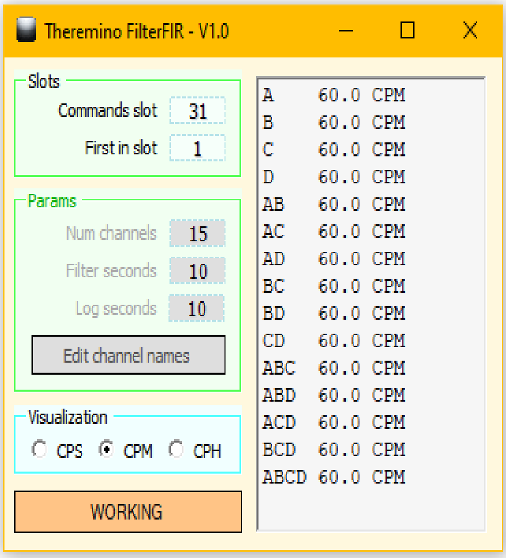
theremino System

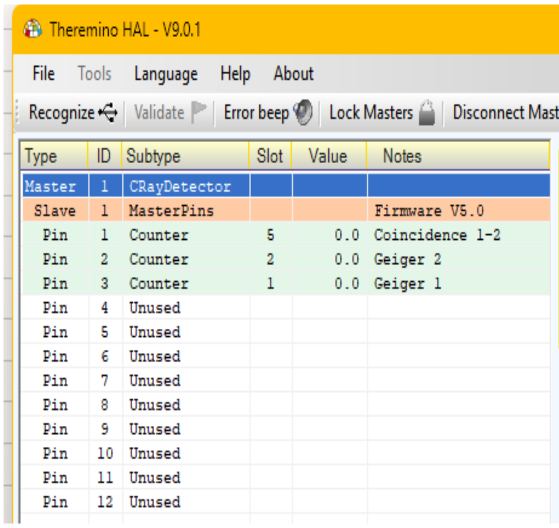
Cosmic Ray Detector HAL and Master version

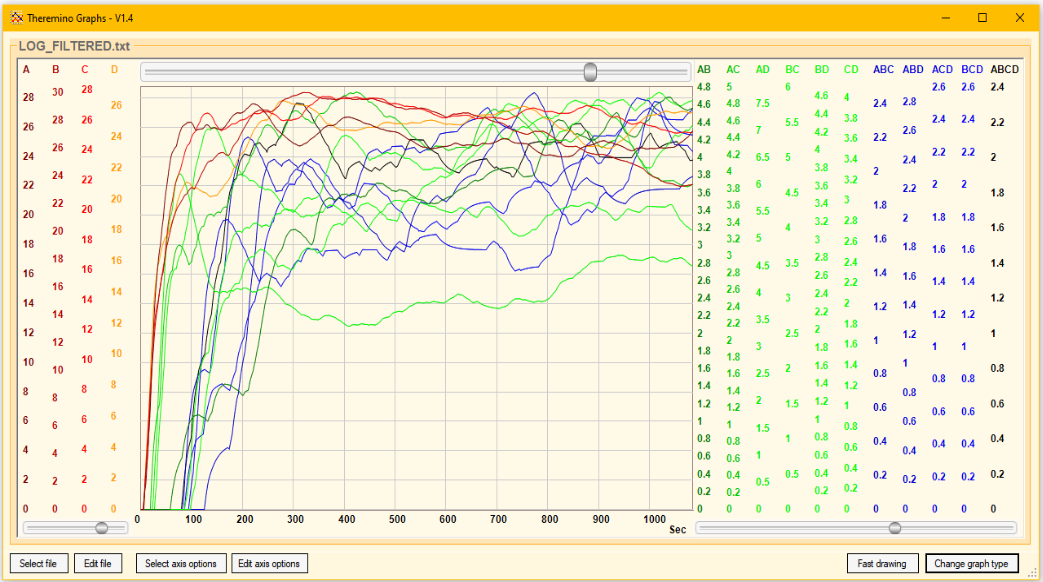
Cosmic Ray Detector - Software

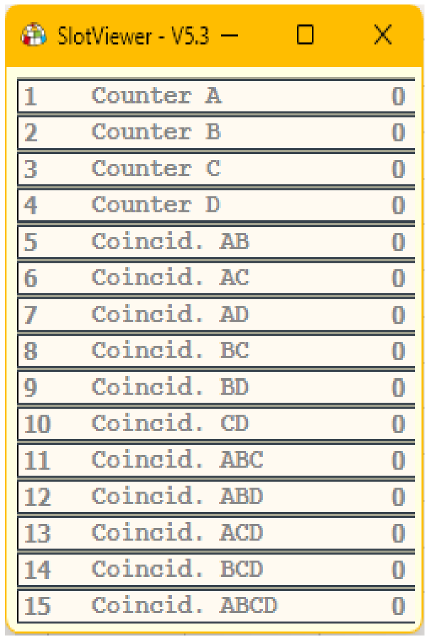


The Cosmic Ray Detector system consists of an application **Theremino Automation**, an application **Theremino FilterFIR**, an application **Theremino HAL** (which reads the **Master module** via USB), an application **Theremino Graphs** and an application **Theremino SlotViewer.**









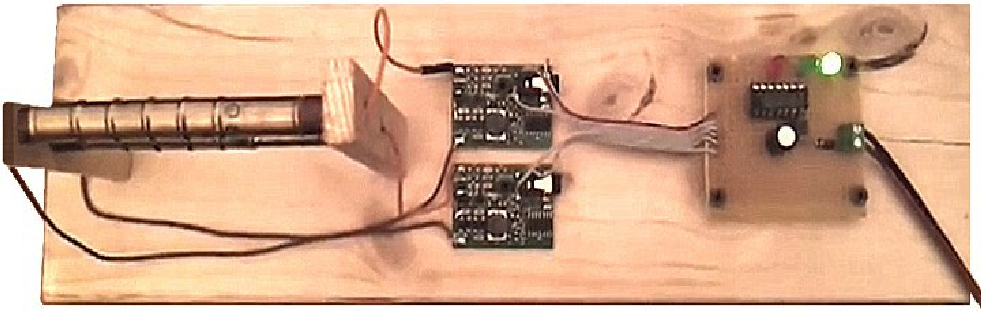
You can minimize unused applications,
they will remain in the bottom bar of Windows and you can reopen them when needed.

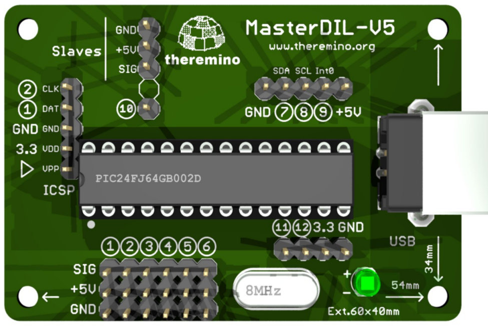
To shut down the entire system
the Automation application closes with the cross in the top right.

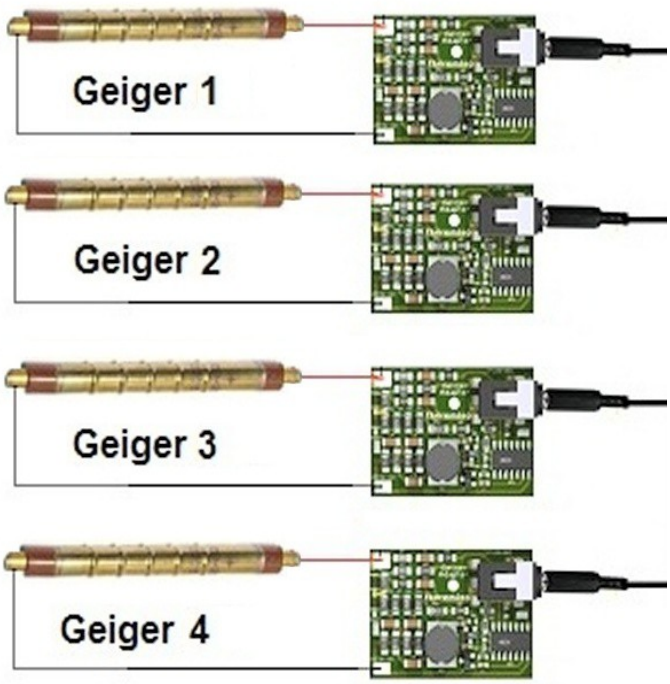
Cosmic Ray Detector - HAL - Hardware

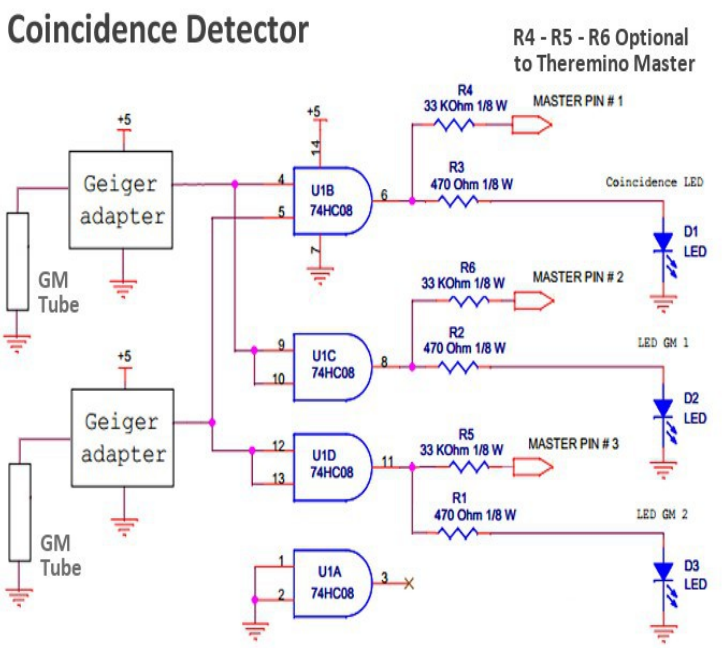
The Master + HAL version of the Cosmic Detector consists of the following hardware:

- A Master module and a PCB board with the components for the coincidences.
- Up to four Geiger tubes connected with GeigerAdapter modules



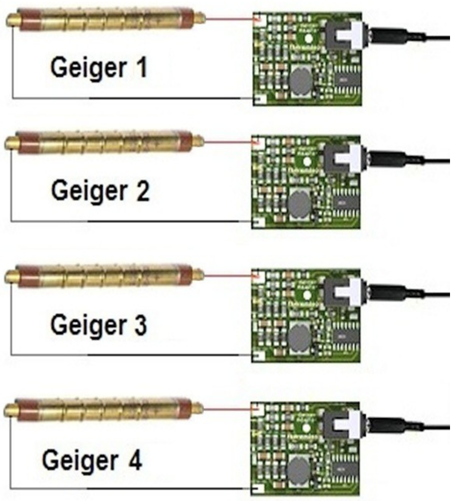




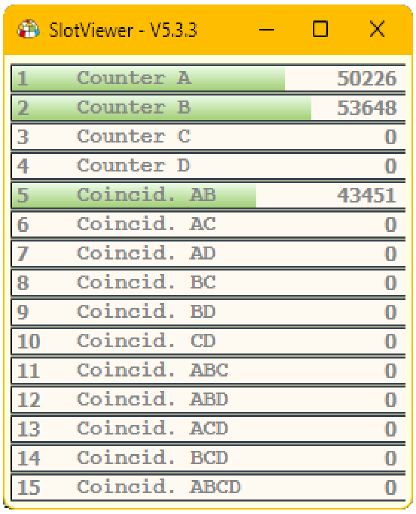


Communications Structure

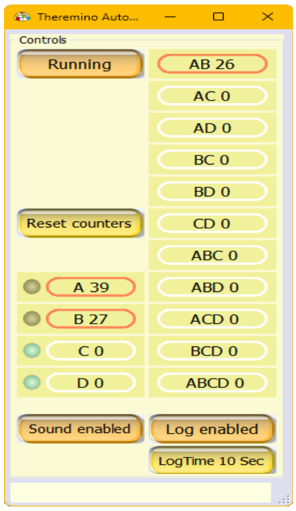
This diagram shows how signals flow from sensors to log files and graphs.



Sensors



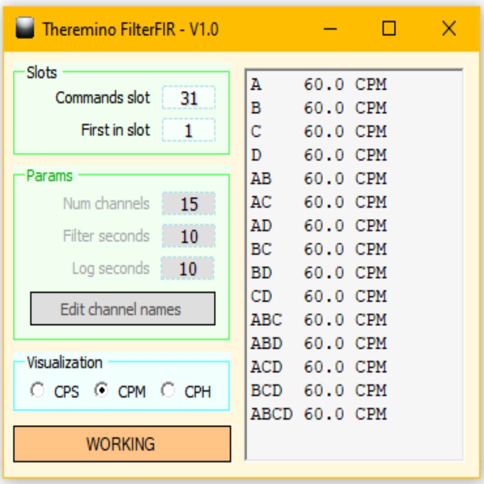
Slot viewer



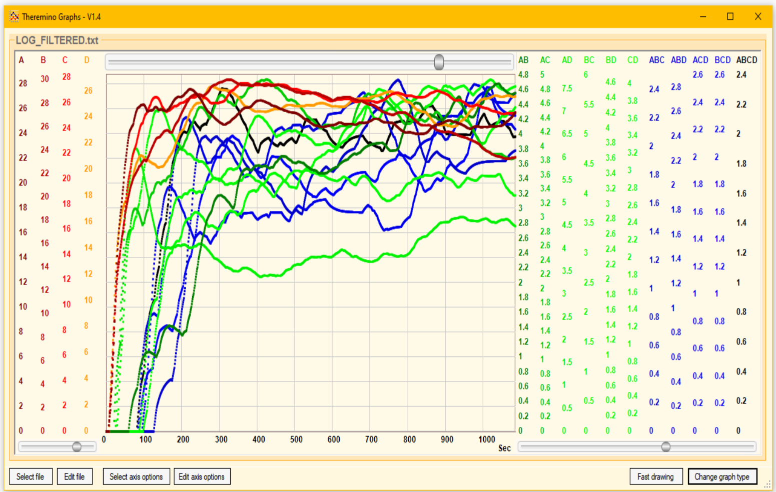
Automation

The application HAL reads the incoming signals from the sensors and sends the raw counts to the Slots, which can be viewed from the Slot Viewer and which are then used by other applications.

If you enable the "Log enabled" button Automation it also writes the "LOG_FILE.txt" file, which contains the raw counts. Counts in the LOG_FILE file are written one line at a time with a timestamp and grow indefinitely without any size limit.



Filter FIR



Graphs

The application Filter FIR reads the raw data from the Slots, filters it and sends it to the "LOG_FILTERED.txt" file, one line at a time with date and time.

The application Graphs reads the "LOG_FILTERED" file and displays the data.

The Cosmic Ray Detector Program

This program

- Reads counts from Slots (which in the default version go from Slot to Slot 15)
- It displays increasing counts and makes a sound with each count.
- Writes raw counts ***(see note 1)*** in a LOG file.

The counts reset to 0 each time you reboot the Nano module or press the "Reset counters" button.

The first button at the top stops or starts the acquisition.

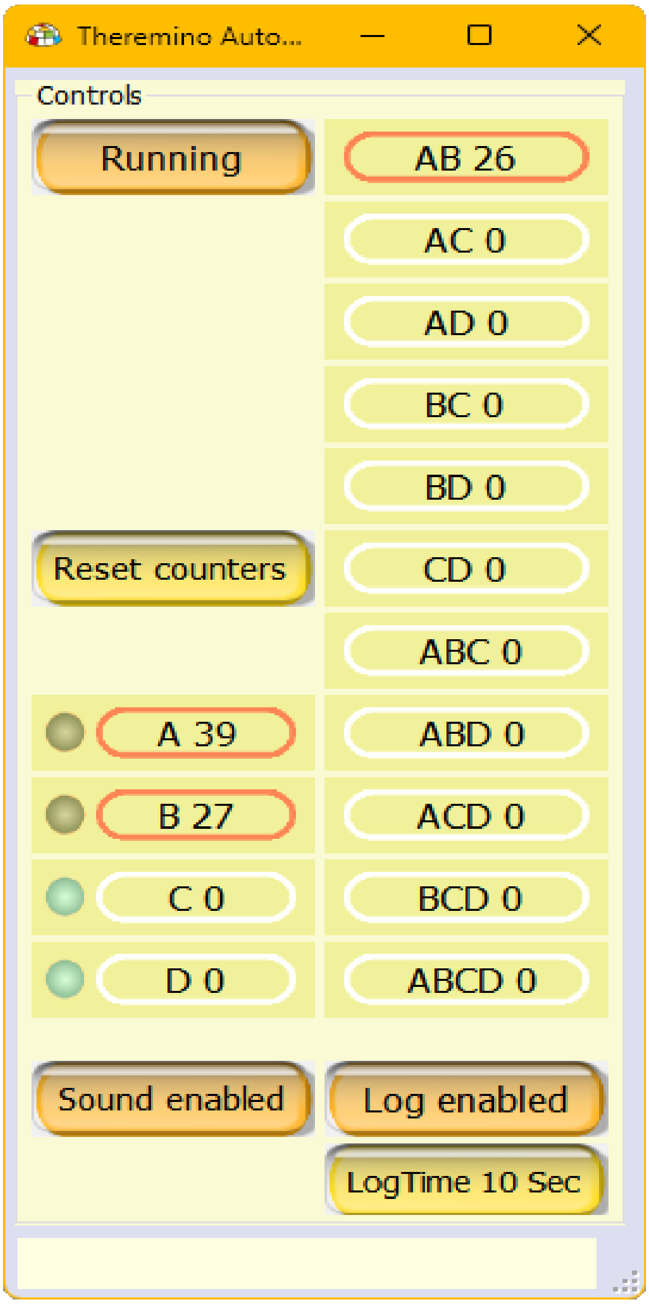
The four boxes A, B, C and D indicate how many pulses came from the Geigers.

The eleven boxes on the right indicate how many coincidences were counted.

If you enable the "Sound" box, a short sound will be emitted for each new incoming Geiger pulse.

In the first lines of the program you can change the frequency and duration of the sound.

If you enable the "Log" box, a new line is written every 1, 10, 30, 60, 120, 180, 300, or 600 seconds to the file located in the LOGS folder.



If you are measuring months or years, the counts in this log file can grow without size limits.

(Note 1) All count numbers in Slots 1 to 15 and in the LOG file are modulus 65536. In other words, they grow up to 65535 and then start again from 0, and this allows even very high counts to be written to the Slots without losing precision.

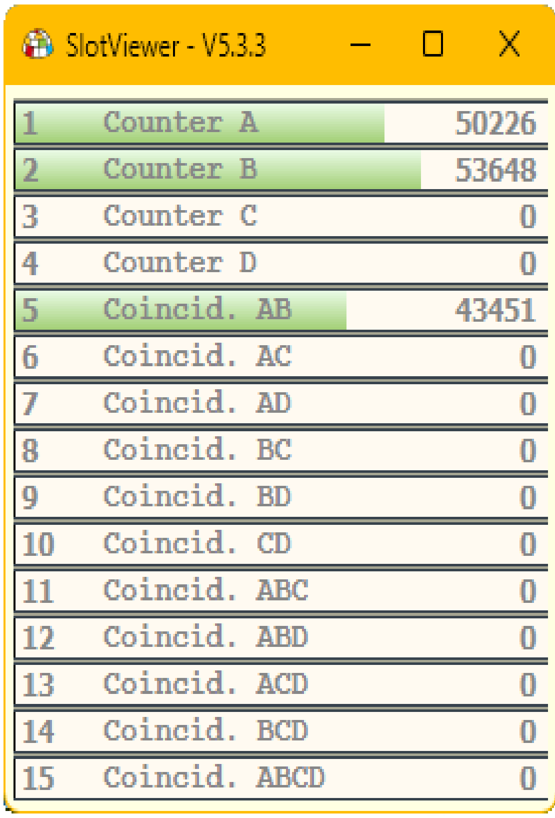
If necessary, the CosmicRayFilters application, and any other applications, will recompose progressive counts that always increase.

The Slot Viewer application

The Slot Viewer displays the values written to the Slots by the Cosmic Ray Detector program.

You don't need to use this application
because all values are already displayed in the main application.

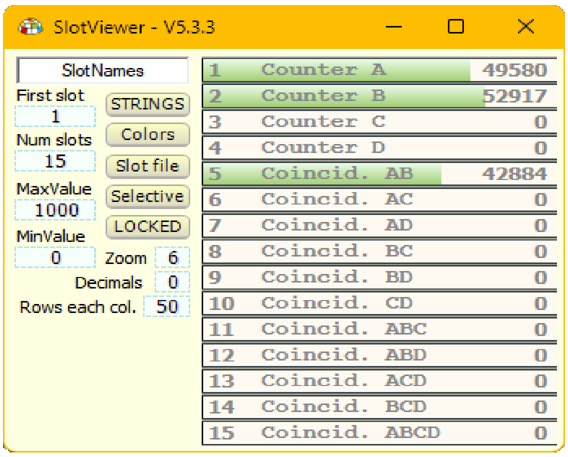
When it is not needed, it is minimized
and will remember this setting later.



- The four counts CounterA/B/C/D indicate the number of pulses that have arrived from the Geiger modules.
- The Coincid. AB/AC/AD... etc.. lines indicate the number of coincidences counted.

The colored bars indicate values with modulo 65536 (16 bits), as explained on the previous page.

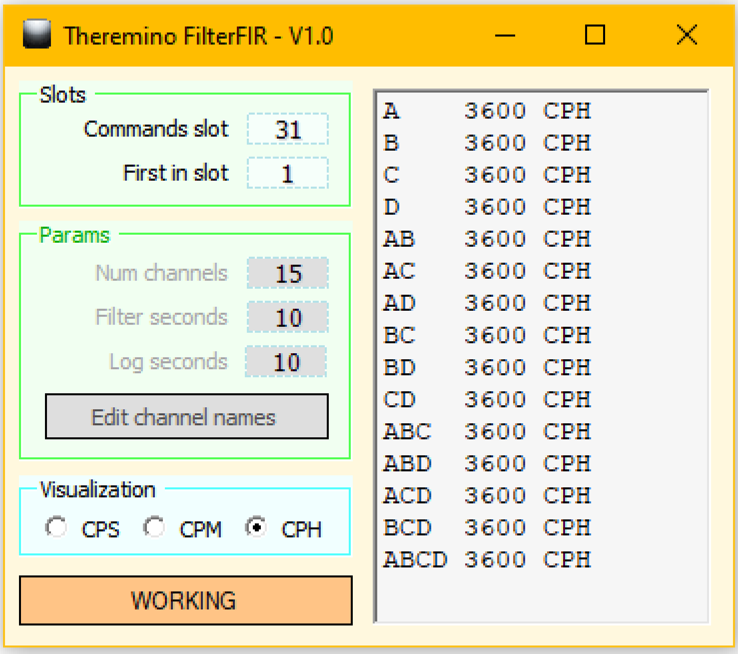
Double-clicking on the top part opens the side part that allows you to change the options.



For more information about SlotViewer, read this page:
https://www.theremino.com/downloads/foundations#slotviewer

The FilterFIR application

This application applies Finite Impulse Response (FIR) filters to the count and coincidence data produced by the Cosmic Ray Detector.

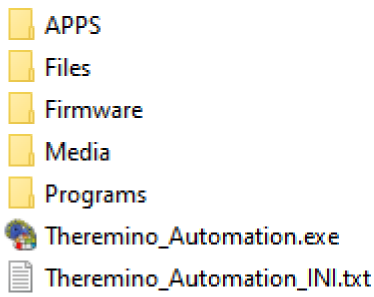


After calculating the averages for all channels this application also writes a file with the name **LOG_FILTERED.txt**

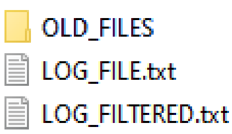
The LOG file contains the date and time for each line and the averaged data of all channels and can be used by applications such as Excel and Theremino Graphs.

Using Theremino Graphs you can see the graph in real time while the LOG is being written.

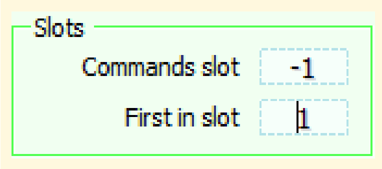
The LOG file is created in the folder **LOGS** always with the same name to facilitate real-time viewing programs like Graphs, but there is a safety mechanism that prevents losing previous files by overwriting them.



Every time a new LOG file is generated the previous one is copied to the folder **OLD_FILES** with the addition of date and time, as in this example:
LOG_FILTERED_2025-01-12_17-59-48.txt



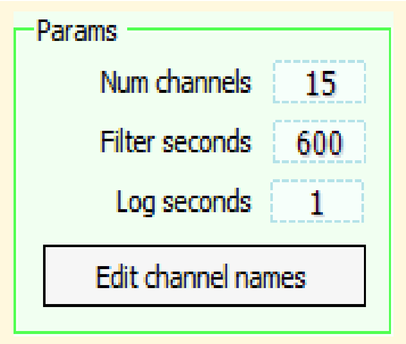
Theremino FilterFIR settings



Commands slot - It is used to receive commands from other applications. This way, all parameters can be adjusted by other applications if necessary.

First in slot - Indicates from which Slots to read the counts and coincidences produced by the CosmicRayDetector.

This must be the same value that is set in the FirstOutputSlot variable at the beginning of the CosmicRayDetector program run by Automation.



Number of channels - To read all channels produced by the CosmicRayDetector, set this box to 15.

Filter seconds - You can average over any time you like by setting this box from 1 to 9999 seconds.

If you set a short time, such as 10 or 60 seconds, you will have a faster response to changes, but the data will be noisier.

Normally for cosmic rays it is set to 3600 seconds (one hour) which is a good compromise to have stable data and a reasonable response speed.

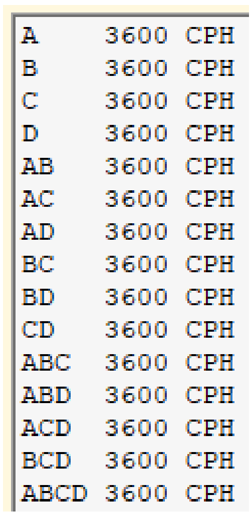
Log seconds - This value sets the interval (from 1 to 600 seconds) between when a new line is written to the log file. Typically, 1 to 60 seconds is used.

Don't use too long times, otherwise the Graphs application will be slow to launch. See the table showing file lengths on the next page.

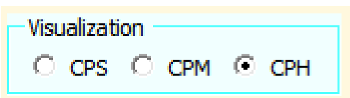
Edit channel names - This button opens Notepad with the channel names, one per line.

For the CosmicRayDetectorI am: A B C D AB AC AD BC BD CD ABC ABD ACD BCD ABCD. Be careful to write them one on each line.

The filtered data is displayed in the right pane and to align it well, more or fewer spaces are added to the names, depending on their length.



In the "Visualization" box you can choose the data scale in counts per second (CPS), per minute (CPM) or per hour (CPH).



This choice will also be used for data written to the LOG file.

The LOG file

The log file contains for each line the date and time and the averaged data of all channels.

In the first part of the file we find:

- The start date and time of the recording (Year, Month, Day, Hours, Minutes, Seconds)
- The number of channels (for the Cosmic Detector it is always kept at 15)
- The seconds over which the FIR data is averaged (1 to 9999)
- How many seconds a LOG line is written (from 1 to 100)
- The unit of measurement in cycles per unit of time, which can be CPS, CPM or CPH
- Channel names

Here is an example of how a log file might start

```
# ------------------------------------
# Session start: 2025/01/14 13:02:27
# ------------------------------------
# Number of channels: 15
#FIR Seconds: 10
#LOG Seconds: 1
#LOG Type: CPS
# ------------------------------------
A;B;C;D;AB;AC;AD;BC;BD;CD;ABC;ABD;ACD;BCD;ABCD
# ------------------------------------
2025/01/14 13:02:28;0.00;0.00;0.00;0.00;0.00;0.00;0.00;0.00;0.00;0.00;0.00;0.00;0.00;0.00;0.00
2025/01/14 13:02:29;0.00;0.00;0.00;0.00;0.00;0.00;0.00;0.00;0.00;0.00;0.00;0.00;0.00;0.00;0.00
2025/01/14 13:02:30;0.00;0.00;0.00;0.00;0.00;0.00;0.00;0.00;0.00;0.00;0.00;0.00;0.00;0.00;0.00
2025/01/14 13:02:31;0.00;0.00;0.00;0.00;0.00;0.00;0.00;0.00;0.00;0.00;0.00;0.00;0.00;0.00;0.00
....
....
```

Here is an estimate of the length of the LOG file, this is an estimate approximate, the exact value depends on how many events occur in the chosen time unit (CPS, CPM or CPH) and therefore on the length of the numbers stored in each row.

Log seconds	By day	Per week	By month	By year
1	6 mega	40 mega	150 mega	2 giga
10	600 K	4 mega	15 mega	200 mega
60	100 K	600 K	2.5 mega	36 mega
600	10 K	60 K	250 K	4 mega

Use times longer than 60 seconds only if you are making logs lasting many months, otherwise the Graphs application will be slow to update the data in real time.

But don't use too short times either, which would result in files of many megabytes, because in this case the Graphs application would become slow during the visualizations. If this happens, set it to "Fast drawing" or limit the number of lines.

Description of the calculation and filtering method

The "Filter seconds" are the counts that fit in the buffer.

For example, if your buffer is one hour long, i.e. Filter seconds = 3600, and you have an activity of 110 counts per hour, then on average there are 110 in the buffer.

At first the buffer is not an hour long but a second, then two seconds, then three... and it grows until it becomes 3600 seconds.

And so during this time the counts in the buffer increase, first one, then two... until they reach about 110.

Then, when the buffer reaches 3600 seconds, older counts begin to fall out of the buffer's tail. New ones begin to enter from the head.

This way, you can get readings even in the first few minutes. They are more imprecise and noisy, but at least you can see something.

Then, as the buffer fills, the precision increases until the buffer is as long as set.

A maximum buffer length is established and the oldest samples are eliminated because if this were not done the buffer would become excessively long and it would no longer be possible to detect variations and once the buffer was weeks long it would then take another few weeks to change the average value.

How to Averaging with a FIFO Buffer

The buffer is a FIFO that is updated every second with the number of events that were received in that second.

Let's say it's 3600 seconds long...

Every second:

- If there is new data it is added to the beginning.
- If there is data whose time exceeds 3600 seconds it is removed from the end.
- Count the values and write them in the box.
- Add all the values and divide by 3600 to get the CPS
- Multiply by 60 to get CPM and again by 60 to get CPH.

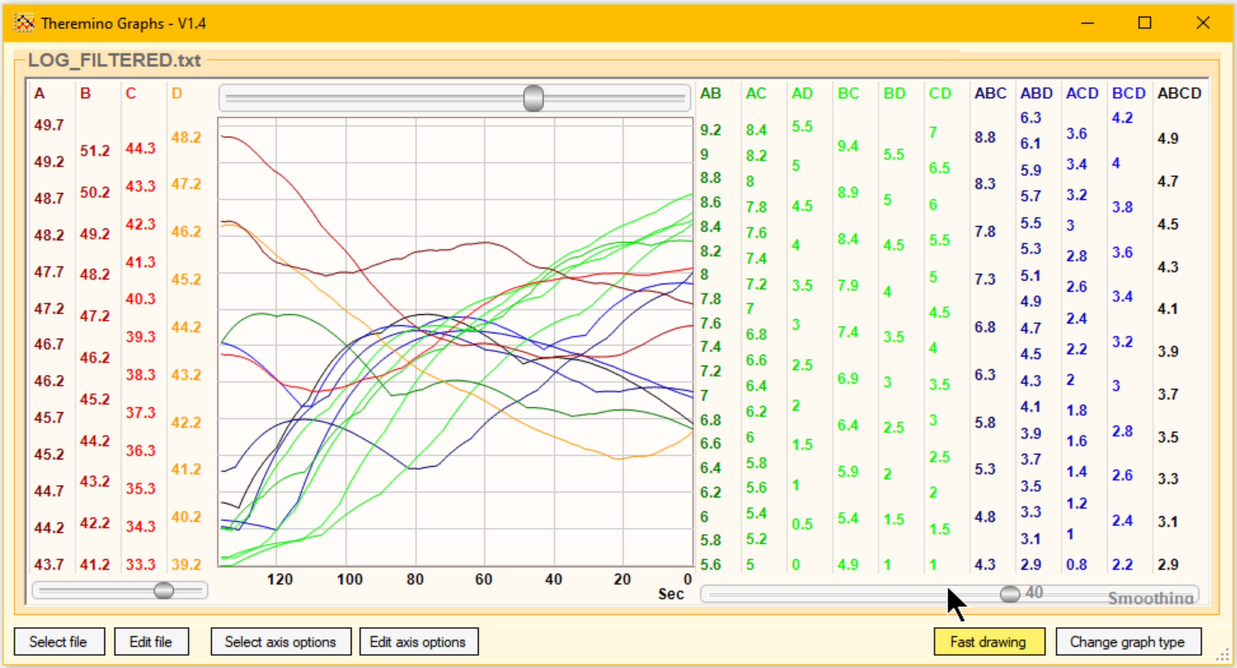
If the FIFO is longer than 3600, different ratios are used to obtain the set unit of measurement (CPS, CPM or CPH).

The type of average produced by doing these operations is called FIR (Finite Impulse Response).

The Theremino Graphs application

This application displays all kinds of LOG files but you will find it already set to display those produced by Theremino FilterFIR

By default, you will find two options rows, one that displays the data as it is and one that displays it with some smoothing (interpolation between sequential values).



The commands are few and intuitive:

Select file - Select the file to view

Edit file - Open the selected file with Notepad to explore it

Select axis options - Selecting the display options file

Edit axis options - Opens the options file (see next page)

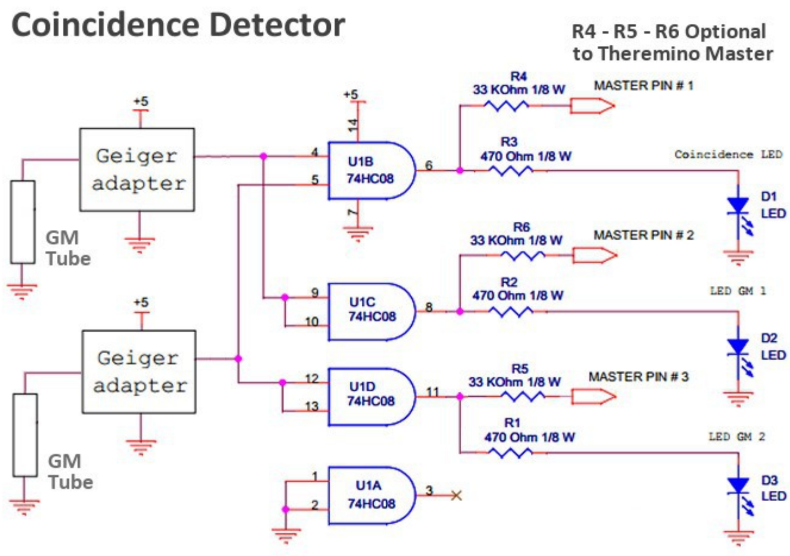
Fast drawing - Makes viewing faster for very large files

Change graph type - Change display mode (lines or squares)

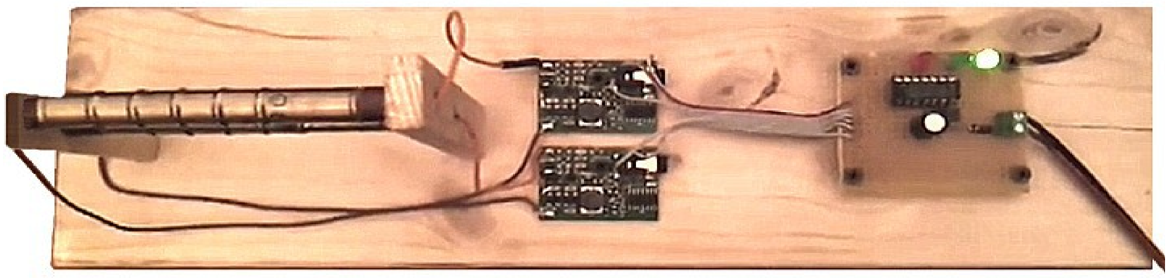
For more information read this page
and above all the file **Theremino_Graphs_Help**

[***https://www.theremino.com/downloads/foundations#graphs***](https://www.theremino.com/downloads/foundations#graphs)

Master Module Connections



This diagram shows where to connect the wires coming from the Geiger Adapter modules and the wires going to the LEDs.



If you don't connect four Geigers but only three you will connect them to A, B and C

If there are only two Geigers, they are connected to A and B.

There is no need to connect the LEDs because the main program already shows everything.

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For more information on electronics, Master modules and the HAL application
Read the documentation PDFs you can find by opening the links below.

https://www.theremino.com/hardware/inputs/radioactivity-sensors#coincidence

https://www.theremino.com/hardware/devices#master

https://www.theremino.com/downloads/foundations#hal

Geiger tubes and Geiger Adapter modules

The Geiger tubes connect to the Geiger Adapter module with two wires.

Please note that there is a + sign on the tubes and it must be connected to the positive (red wire in these pictures).

If possible, keep the positive wire as short as possible, while the negative (GND) can be as long as desired.

At the output of the Geiger Adapter module you will have three wires GND +5V and Signal.

All GNDs go together with the Dwarf's GND.

All the +5s go together to the +5V of the Nano.

And the four signals each go to one of the Nano's A, B, C, and D inputs.