

ROOTSCOPE Manual

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1. Introduction

Initially, I just plan to write some short macros for learning how to add hotkeys to ROOT and play around ROOT GUI. I would haven't thought that the project become such long. My original motivation is very simple that is to make the process of Gaussian fit with background quicker – just using mouse to select the range of background and then set the range of fit. This learn project gradually evolves into the ROOTSCOPE as I will present here, and I hope ROOTSCOPE can help your analysis.

In a nutshell, ROOTSCOPE is a ROOT GUI application designed to deal with general analysis for 1d and 2d histogram, such as browsing the histogram, find the peaks. ROOTSCOPE is inspired by “Gnscope”, which is a software I used heavily during my Ph.D. study for gamma-ray spectroscopy analysis. ROOTSCOPE tries to provide the same user experience as Gnscope does; many complex tasks can be done by just a couple of key strokes.

ROOTSCOPE mainly attempts to make the following categories of data analysis easier:

- (1) making projections from a 2d histogram with background subtractions,
- (2) organizing and browsing 1d histograms,
- (3) getting the fit of a peak or finding the peaks automatically.

ROOTSCOPE program comes from my learning project. I have to profess that for the internal functions, I may not strictly follow the ROOT naming conventions. One will see something like “To_display_histos()” in the source codes. Fortunately, the code structure of ROOTSCOPE is easy to understand. Meanwhile, I also have a lite version – “ROOTSCOPE-lite” that has 1d core functions. The lite version is much easier for one to add new customized hotkeys or functions. If you would like to contact me, please use pt10f@my.fsu.edu to email me. Thank you very much.

2. How to run

This section describes the file structure and how to get the access of ROOTSCOPE class. There are 3 files: “myROOTSCOPE.C” is the main macro, and the class ROOTSCOPE is written in it. “myDialog.h” contains the dialogues used in ROOTSCOPE, and “myUtility.h” is for the calculations.

Just like other macros, to run the macro, at the terminal you can enter: *root myROOTSCOPE.C*. Then ROOTSCOPE class is load and myROOTSCOPE() function will be executed. myROOTSCOPE() function aims to provide very simple examples for how to use the 4 different class constructors of ROOTSCOPE.

```
root myROOTSCOPE.C
root [0]
Processing myROOTSCOPE.C...
~Test~
```

When you at root prompt, type in `“.x myROOTSCOPE.C+”`, and that will call ACLiC to compile myROOTSCOPE.C and then create a shared library -- `“myROOTSCOPE_C.so”`. You can load this library in your `“.rootlogon.C”`. In this way, when you call the root in this folder, the ROOTSCOPE class will be automatically loaded and you don’t need to compile it.

```
{  
    gSystem->Load(“./myROOTSCOPE_C.so”);  
}
```

Public member functions:

// constructors

ROOTSCOPE::ROOTSCOPE(const TGWindow * p, TH1* histo_input)

ROOTSCOPE::ROOTSCOPE(const TGWindow * p, TH2* histo2d_input)

ROOTSCOPE::ROOTSCOPE(const TGWindow * p)

ROOTSCOPE::ROOTSCOPE(const TGWindow * p, const char* rootFileName)

TH2* ROOTSCOPE::GetTwoDHisto();

TH1* ROOTSCOPE::GetOneDHisto(); // to get the current selected histogram.

TString ROOTSCOPE::GetMessage() // to get the text in the message box.

void ROOTSCOPE::SetTwoDHisto(TH2* h2d_input);

void ROOTSCOPE::AddOneDHisto(TH1* h_input); // to append a histogram to our histogram pool.

If you put a 2d histogram into the constructor, ROOTSCOPE will include this 2d histogram, and it automatically create two 1d histograms of the full X and Y range projections into the histogram pool. If you set a root file in the constructor, it reads all the 1d histograms, but just keep the last 2d histogram. In other words, only one 2d histogram is allowed to be in ROOTSCOPE. You can load nothing initially, and then use AddOneDHisto() and SetTwoDHisto to add/set the 1d/2d histograms into ROOTSCOPE.

3 Issues for ROOT version 5

When I develop ROOTSCOPE, I use ROOT version 6.06.06. Although there is no error during the compilation process by ROOT version 5 (5.34.36), unfortunately, the program will behave weirdly and it seems there is no quick fix. I believe it should be possible to run it in Version 5, but it may be not in my top priority list. The good thing is that the lite version works both for version 6 and 5.

4 User Interface

The section here describes the user interface and the basic usage of ROOTSCOPE. The GUI interface of ROOTSCOPE is extremely simple. There are just two parts: one message box at the top, and a canvas for the display of histograms at the bottom.

Any default ROOT hotkeys/ right click content menu/etc... are still available. For example, right click the histogram will pop up the object-corresponding menu. And you can still use “ctrl+s” to save to file.

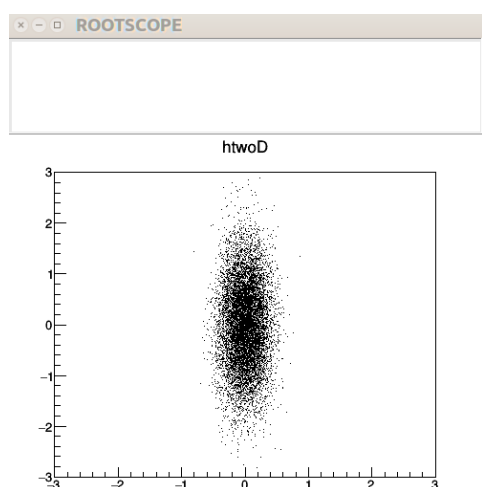


Fig: The GUI interface of ROOTSCOPE.

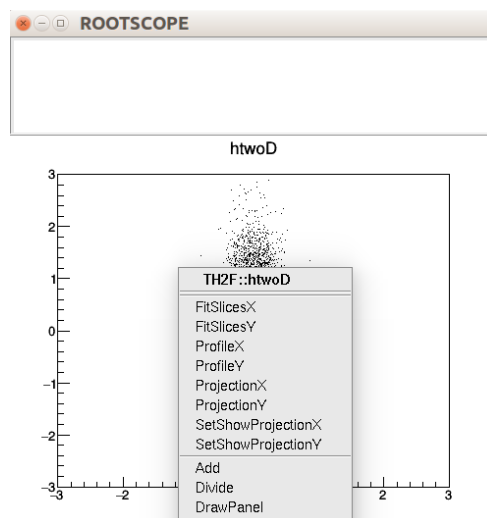
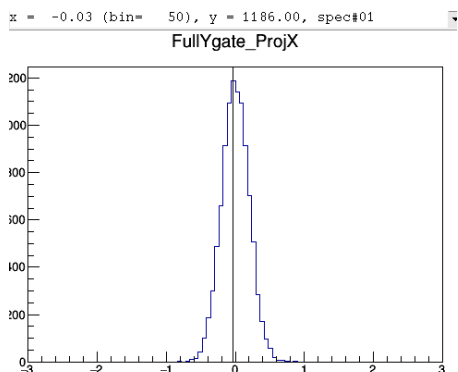


Fig: The original ROOT defaults still available.

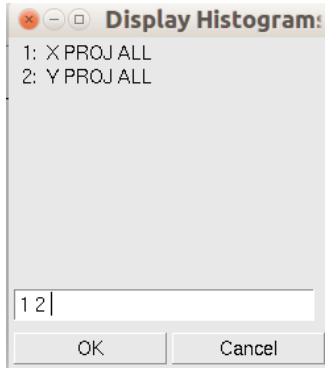


The Mouse left click is set to investigate the position or to set the range which the action will be applied to. For example, when you click anywhere on the canvas, you can see the corresponding x (or histogram bin) and y (or counts) at the message box.

5 Display and switch histograms

Hotkeys: d, q, ctrl+q

Switching histograms are very commonly in the analysis in general. Pressing “d” will pop up a dialogue to show all the 1d histograms.

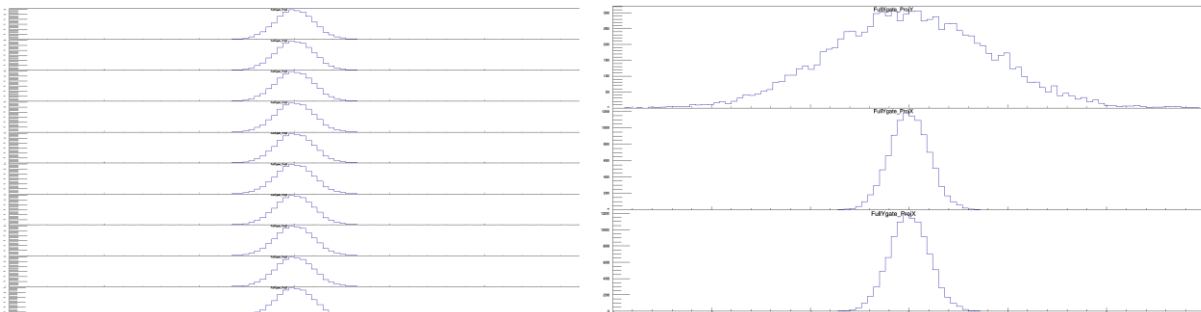


In the "Display histogram" dialogue, the text entry is already set focused, and so you can immediately type in the numbers of spectra you want to open. Once you finish selecting the histogram(s), you can press “Enter” key or click the “OK” button. Press “Esc” or click the “Cancel” button to cancel the display.

The rules for the input.

- (1) numbers have to be separated by spaces. (ex. 1 space 2 space)
- (2) the order corresponds to the order in display
- (3) repetition is ok
- (4) the number larger than the total histogram number will be ignored.
- (5) Max 10 histograms can be displayed at the same time.

For example, when you type in like “ 2 1 1 99”. There will be 3 histograms shown. The first pad displays the histogram no.2, and the second and third will display histogram no.1. Since we don’t have histogram no.99, and there is no display.



“q” / “ctrl+q”

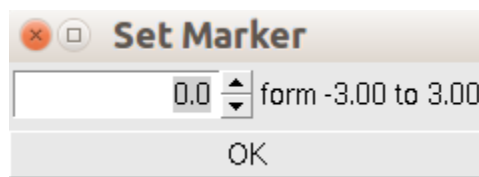
The two hotkeys allow you to switch back and forth between the 2d histogram and present 1d histograms. “ctrl+q” is to switch to display of the 2d histogram. “q” is to switch to display of the 1d histograms. Note: when you have a 2d histogram with a very high number of bins ex (6000 by 6000), the display will be very slow. And if you don't let the display te be finish, and put a new command, then ROOTSCOPE is prone to crash.

6 Set Marker lines and Clean them

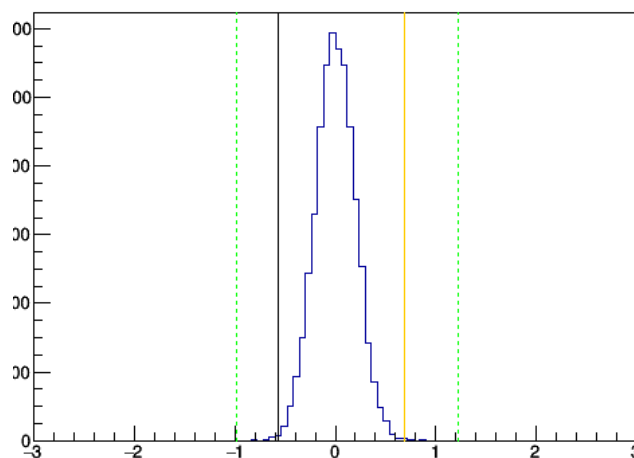
Hotkeys: m, alt+m, left click, ctrl + left click, n.

Marker lines are used in many situations. For example, it can represent the gate range, the expansion range, the fit range, and more.

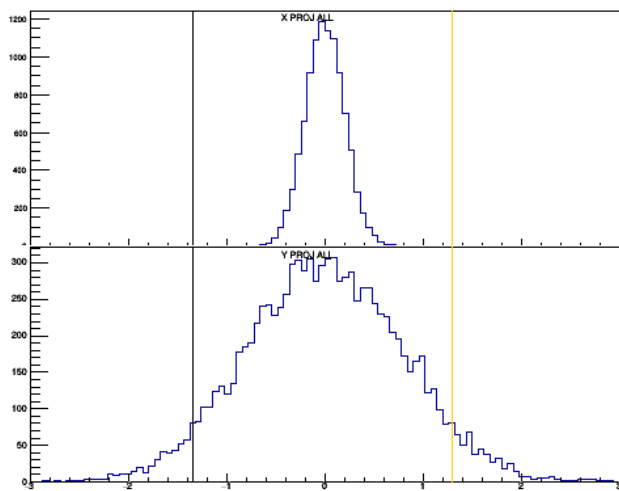
The easier way is just to use a mouse to click the location or type "m", then you can see a maker line. For more precisely input the marker line location, use "alt+m". The marker lines are in black and yellow colors, and the black one is the one you just click, and the yellow one is for your previous click.



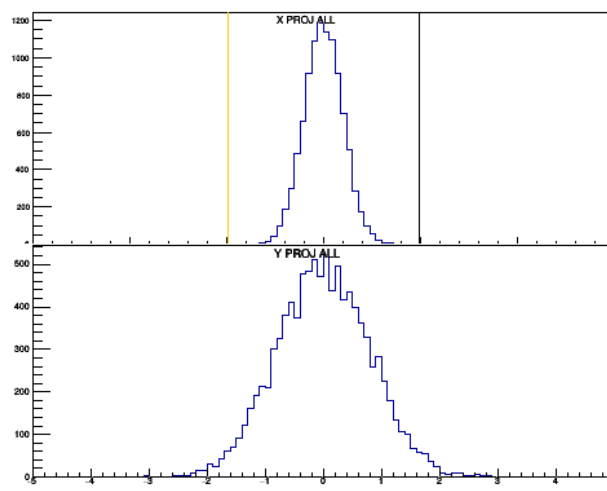
For 1d histogram case, there is another set of markers lines. They are in dash green color, and they can help us to do more complicated input like setting initial values for double gaussian fit or the projection by add-subtract gate regions. They can be set by "ctrl + left click" for a 1d histogram.



Under the multiple pad case, if we have the same dimension for all the displayed histograms, the marker lines are drawn at all the pads. If not histograms don't have the same dimensions, the marker lines are drawn at the selected pad Only. In both cases, the position at the marker line are recorded.

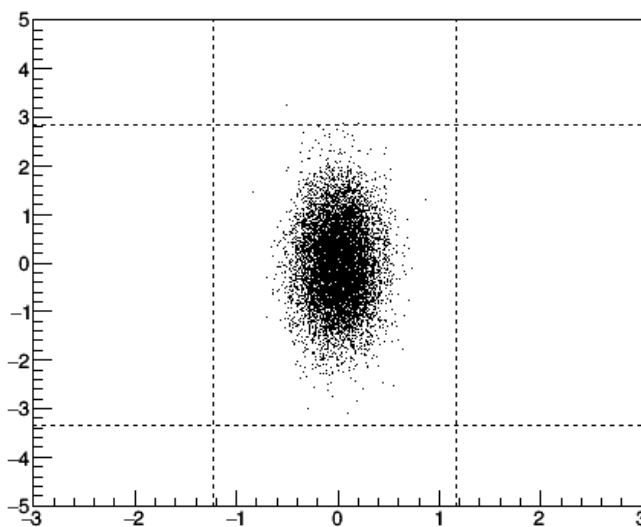


(markers for the same dimensions)



(markers for different dimensions)

For the 2d histogram, we use “ctrl + left click” to set up the set of marker lines. It is to avoid to trigger the default behavior for zooming in.

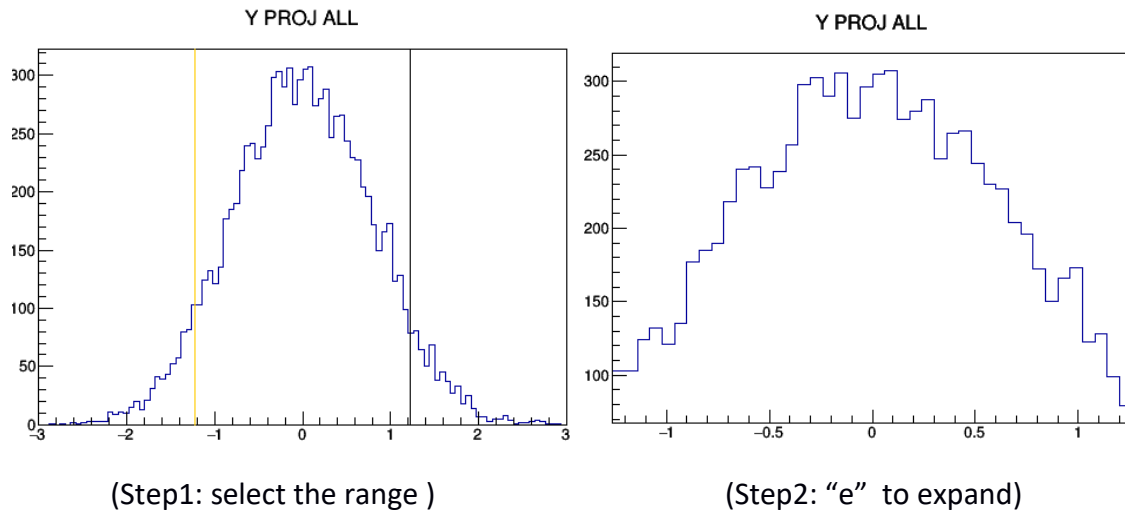


Finally, to clean the marker lines or polymarkers, fitting line , use “n” key.

7 Expand and undo expand

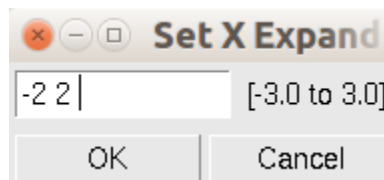
Hotkeys: e, E, o

After we set the two marker lines to select the expansion range. Press “e” key, then we can expand. It is equivalent to use SetRangerUser function.

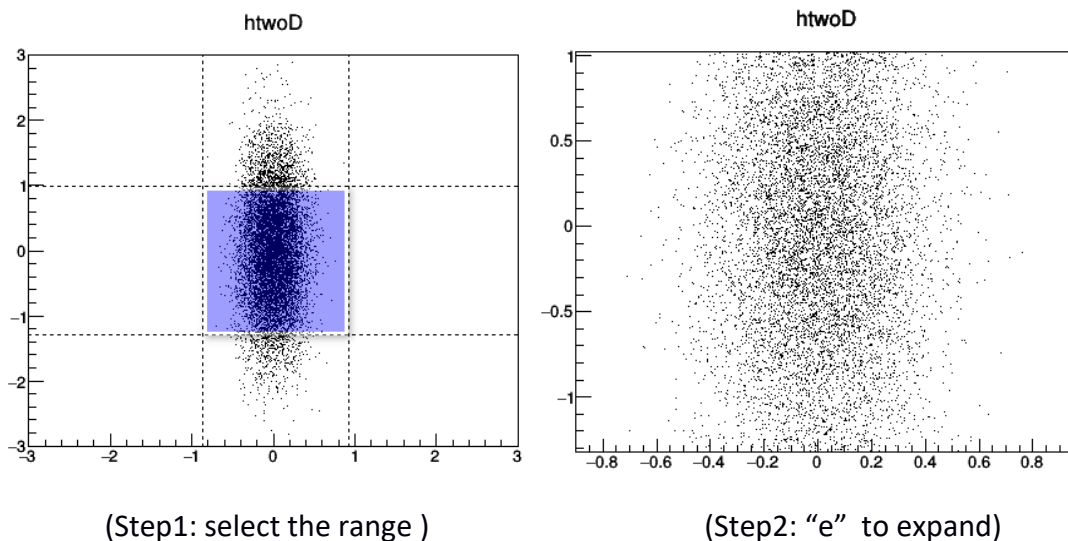


To undo expansion, press “o” for zooming out. It will display the histogram at its full range.

To expand at a given range, press “E”. It will pop up a dialogue for you to input. The two numbers have to be separated by “space”.



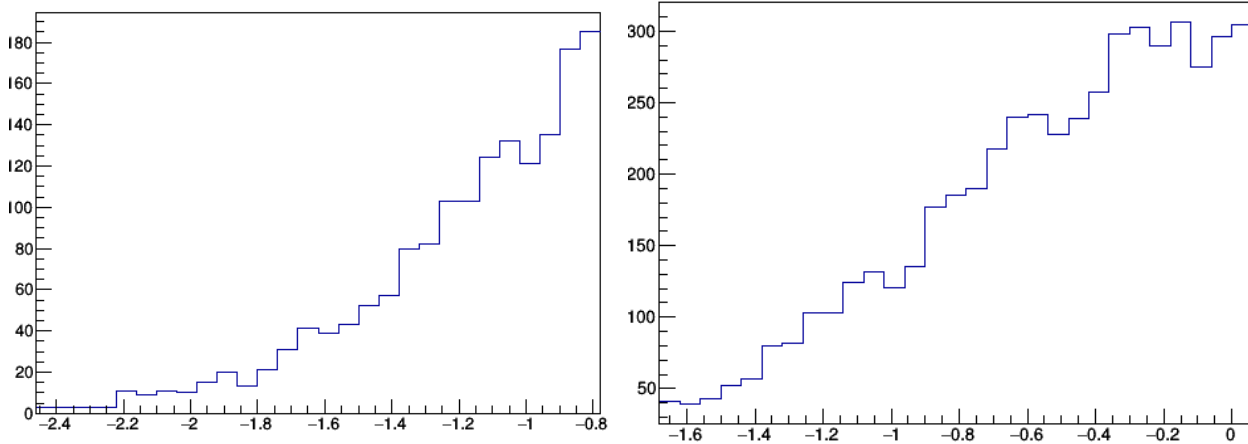
For the 2d histogram, the process is the same: “e” key for expansion, and "o" for zooming out.



8 Arrow keys to navigate histograms

Hotkeys: arrow key up, down, right, left

For right/left arrow keys, you can move to right/left of a 1d histogram. It is very handy to explore the 1d histogram. Note: you will see a sudden blink, that could be the update speed is not fast enough.



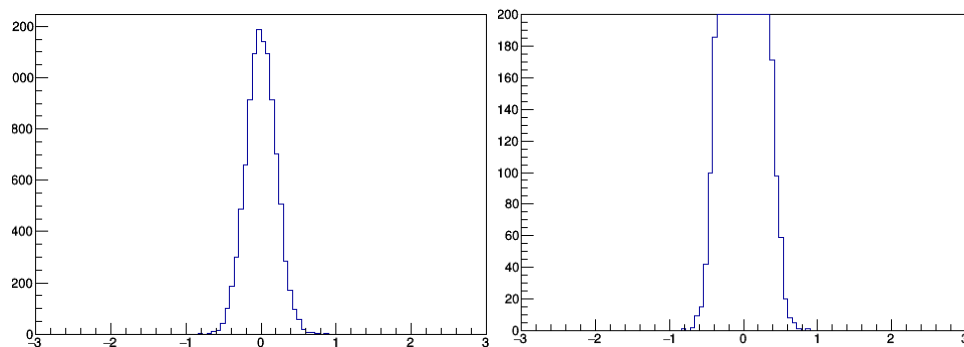
(Using right/left arrow keys to change the x range)

For up/down arrow keys, you can switch a histogram while keeping the same expansion range. "up arrow" key for increase the spectrum number, and vice versa.

9 Set y/z limit in display for a 1d/2d histogram.

Hotkeys: y, z, Z

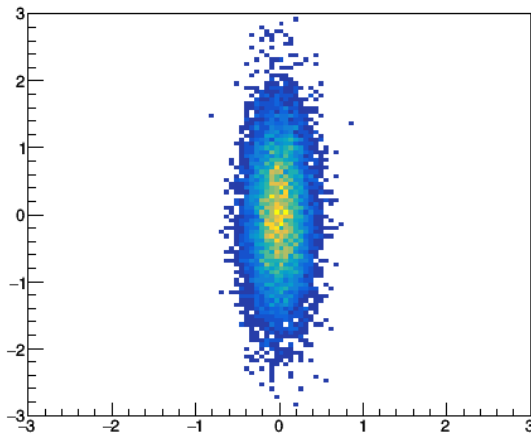
For a 1d histogram, to set the upper limit of y in the display, use "y" key. It will only show y from 0 to the y_upperLimit. To reset to the y_upperLimit to its default value, use "o" to zoom out.



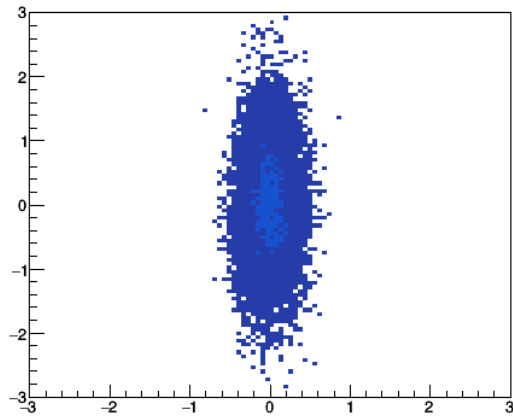
(default value)

(set y upper limit to 200)

For a 2d histogram, “z” to set the upper limit, and “Z” to set the lower limit. All the z values will be in $z_{\text{lower}} \leq z \leq z_{\text{upper}}$. Use “o” to reset to its upper and lower values. It is useful to remove noise, or to clean up the 2d histogram before we do projections.



(default value)

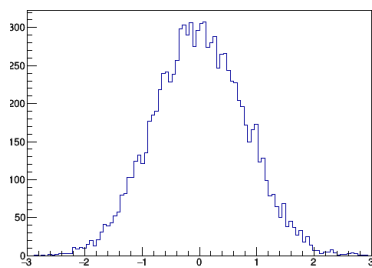


(set upper and lower limits)

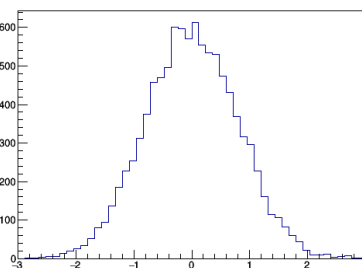
10 Rebin and Undo Rebin

Hotkeys: x, X, y, Y

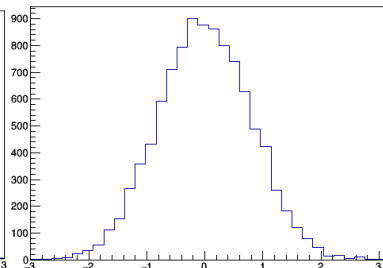
For a 1d histogram, “rebin” will change the number of bins in the x axis; in other word, the bin width increases. “x” key is to increase the degree of rebinning by 1. "X" is to decrease the degree of rebinning by 1. After rebinning, you can freely restore to its original binning.



(cmp=1)



(cmp=2)

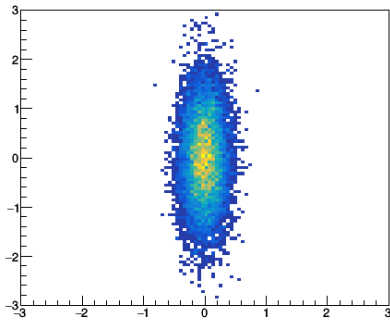


(cmp=3)

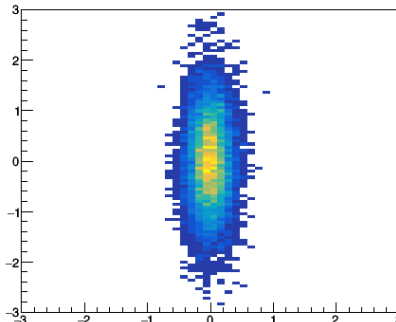
For a 2d histogram, we have two axes.

To rebin/undo-rebin x axis, use "x"/ "X" keys.

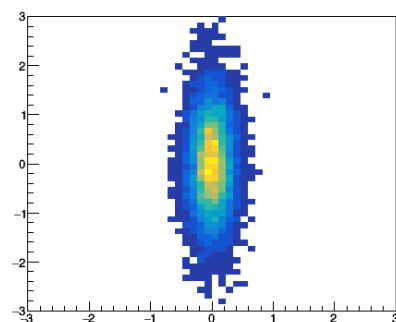
To rebin/undo-rebin y axis, use "y"/ "Y" keys.



(cmpx=1, cmpy=1)



(cmpx=2, cmpy=1)



(cmpx=2, cmpy=2)

11 Set bg value, Gaussian Fit, and Sum

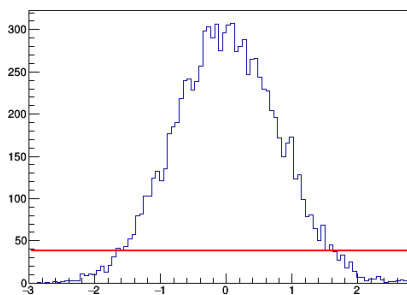
Hotkeys: b, alt+b, 1, g, G, s

Before doing a gaussian or double-gaussian fit, users may desire to set a background value. The bg (background) has two forms:

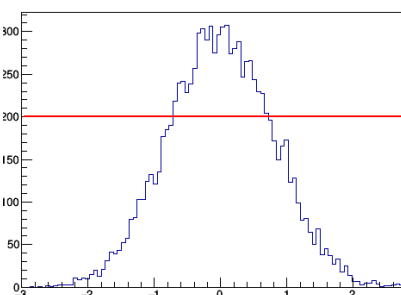
(i) just a const value: $bg = \text{const}$

(ii) linear: $bg = \text{const} + \text{slope} * x$

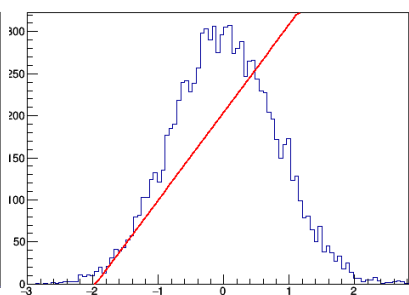
Use "b" key to get the constant background, it will take an average of the counts in the selected background range. Note: use mouse left click to select the range, and then hit "b". Similarly, use "1" key to get the linear background. To set a specific constant background value, use "Alt+b".



(set the range, and hit "b")



("alt+b" to setbg to 200)

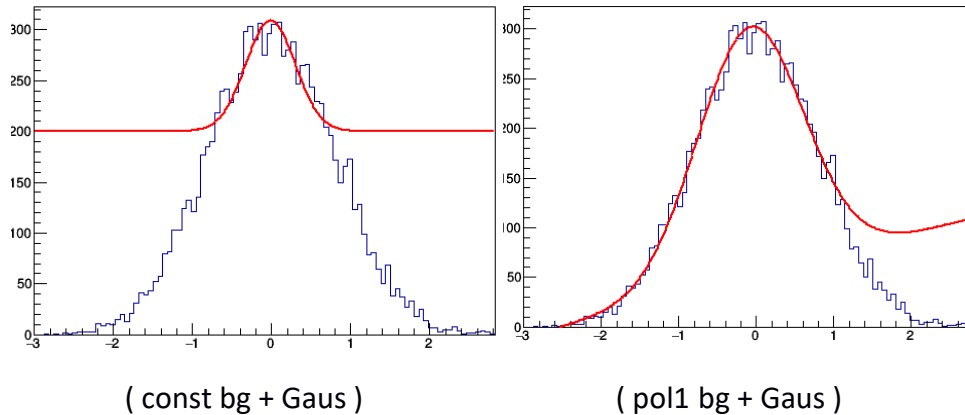


("1" for pol1 bg)

To clean the bg line, press "n". Note: the bg value is still there, just the line is not in display.

For doing a fitting, first we select the fitting range, and press “g” to fit a Gaussian function.

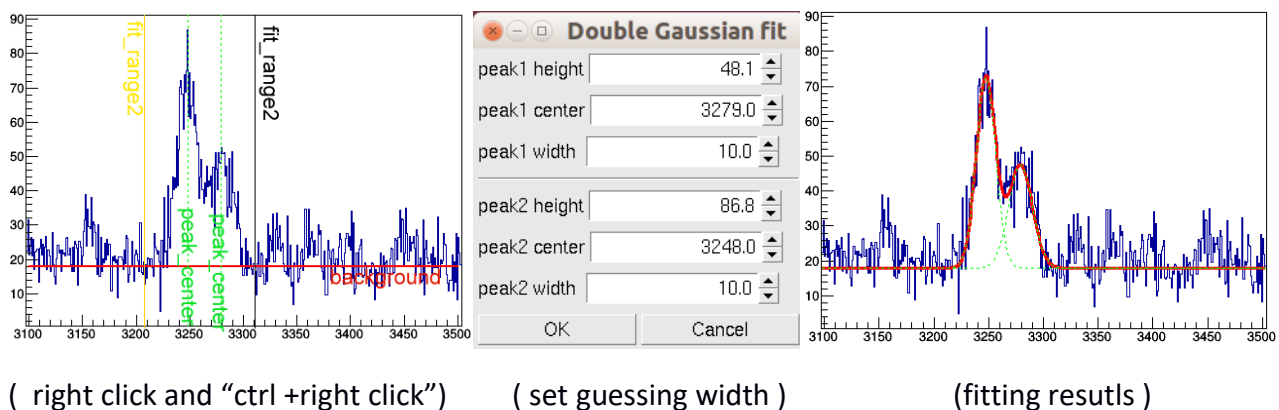
Center = -0.08, Area/cmp = 431.65, FWHM = 2.94, Chisqr/N = 1.01



To do a double-gaussian fit, there are more initial values to set. To faster the input process, I design the auxiliary marker lines.

The procedure of doing a double-gaussian fit.

- (1) set the background, either a const or a linear background.
- (2) set the range of fitting by mouse right click (black and yellow line)
- (3) set the peak-center locations by "ctrl+ right click"
- (4) "G" to open the dialogue, and input the width.
- (5) if the fit is not good, use "G" again to try different width.



(right click and “ctrl +right click”)

(set guessing width)

(fitting results)

For a 1d histogram, after setting the range, press "s" to get the sum of the area. For a 2d histogram, "s" key return the counts of the selected region. A good trick to check whether 1d/2d is empty or not is to use "o" which will set the markers at the two ends of a 1d/2d histogram, and then "s" will get the information for the full range.

NOTE:

The area vs counts.

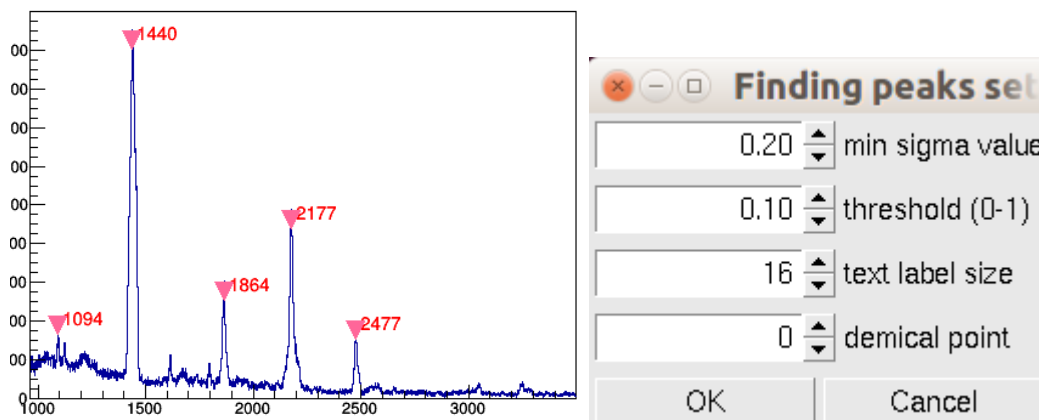
Area = base * height. For a histogram, we refer its y value to counts and Base is the bin width. And so only if bin width = 1, area = counts. Let's say if we apply `rebin(2)` for a peak, the y values approximately double due to the bin width doubles, but the x range of the peak doesn't change. It means the area will be double as well for the same a range of a same peak after rebinning!! To resolve this issue, I use "area/cmp" to represent the area.

12 Finding peaks

Hotkeys: f, ctrl+f

Use "f" to find the peaks. It will add a set of text labels and polymarkers on the screen to indicate the found peaks. This function can very quickly give you the main idea of a spectrum.

To control the threshold and sigma values when searching the peaks or the size of text labels, use "ctrl + f". The threshold is the cutoff value for the peak if its height is less than a certain ratio of the local highest peak, where the default threshold is 10%. The smaller the sigma values are, the more peaks will be identified. Currently, the maximum found peaks are set to 100.

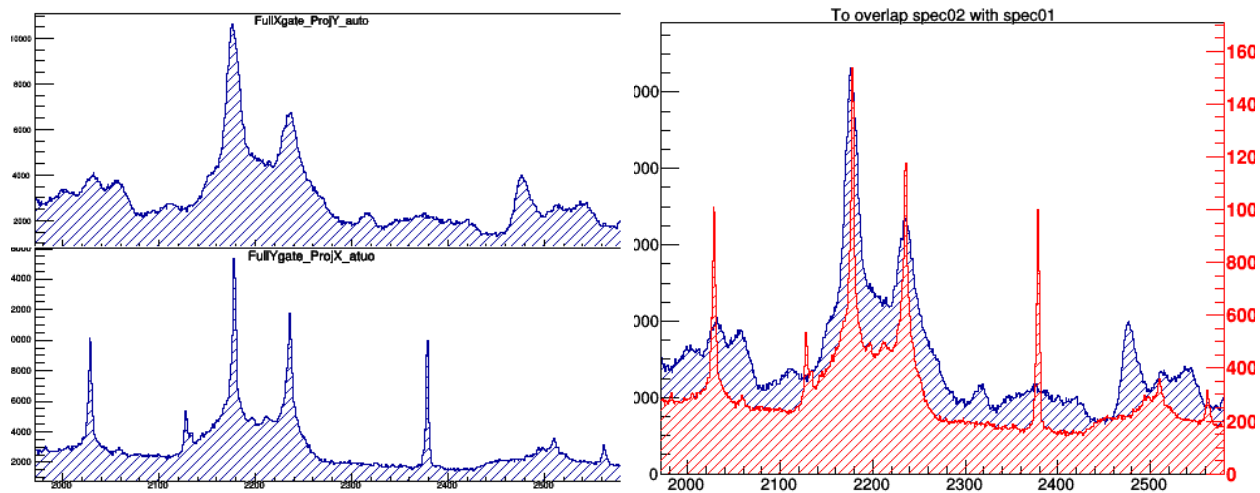


13 To overlap two 1d histograms

Hotkeys: c, ctrl+d

When we have two 1d histograms displayed, "c" key can overlap this two histograms in one pad. Press "c" again, it will back to original display with two pads.

If the two histograms not in the same dimensions, ROOTSCOPE will use the top histogram as the reference to find the common x range, and then do the overlapping of the top and bottom histogram. The bottom histogram will be red color. The filling style attribute will be kept in the overlap mode.



"ctrl+c" pop up a dialogue and allow you to select two histograms to be overlapped. The numbers have to be separated by space.

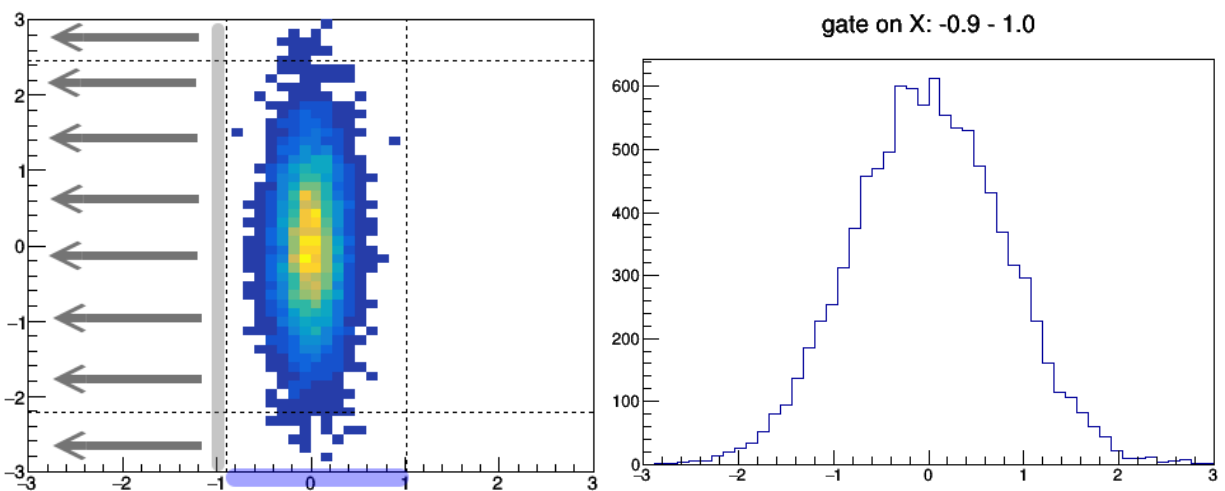
14 Projection

Hotkeys: p, P, ctrl + p

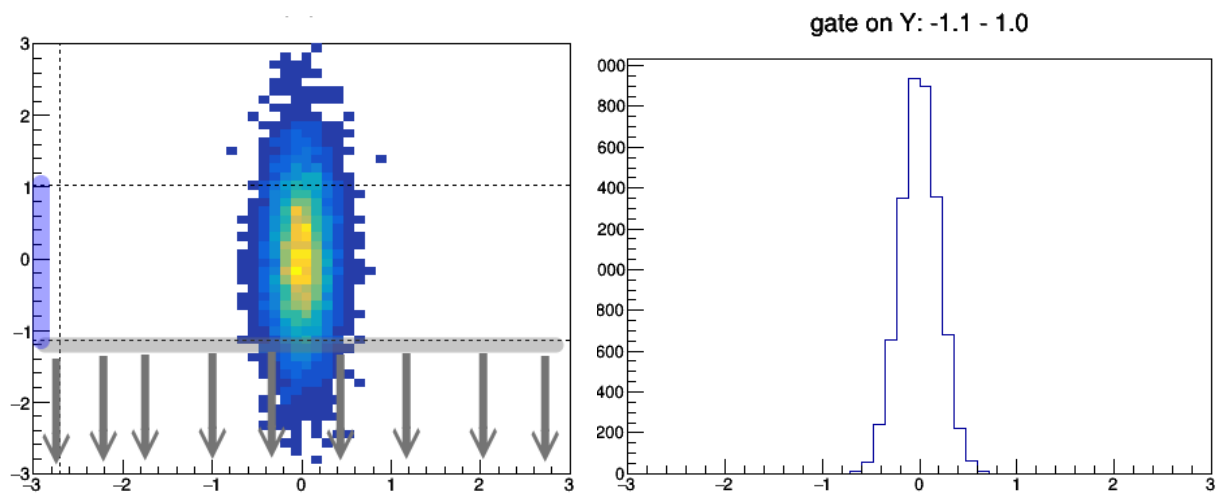
The concept of the projection may be difficult for the users who haven't encounter before. Projection or gating is a way to check the coincidence relationship. The gating is to only select partial range, and the projection is to create a 1d histogram, where its counts are accumulated from the given selected range.

“p” for gating on x axis, and then project on y axis.

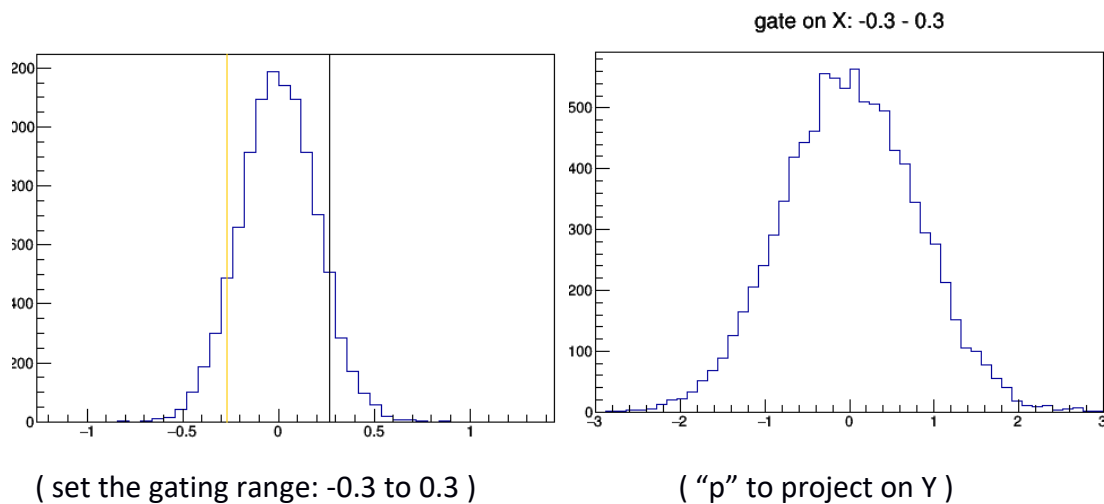
“P” for gating on y axis, and then project on x axis.



(“p” for gating on x, projecting on y)



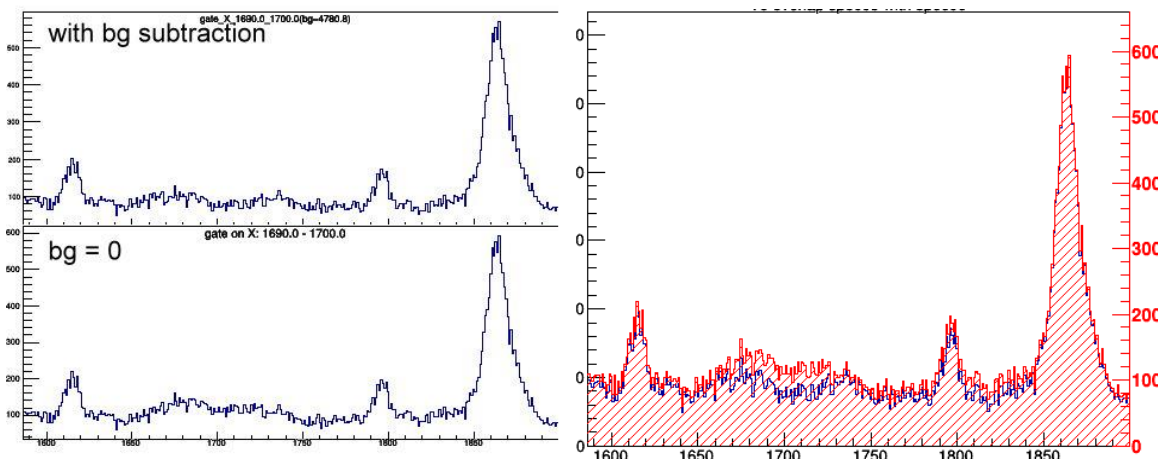
(“P” for gating on y, projecting on x)



After setting the range by mouse right click, both 1d and 2d histogram use the same "p"/"P" keys to control the projection direction. Since the 2d histogram may response slow, it is easier and recommended to set the gate range in the 1d histogram.

NOTE: a trick to make a full range projection: type "o" to zoom out and set the makers at the two ends, and hit "p" or "P" to do the projection on Y or X axis.

If you have background set, then "p" / "P" will apply the fractional background subtraction. The true coincidence peak will be more clear.



"ctrl + p" allows you to see a set of range for add gate and subtract gate.

This background subtraction concept is to produce two histograms from two sets of ranges – real data and background.

The procedure of using add-subtract gate.

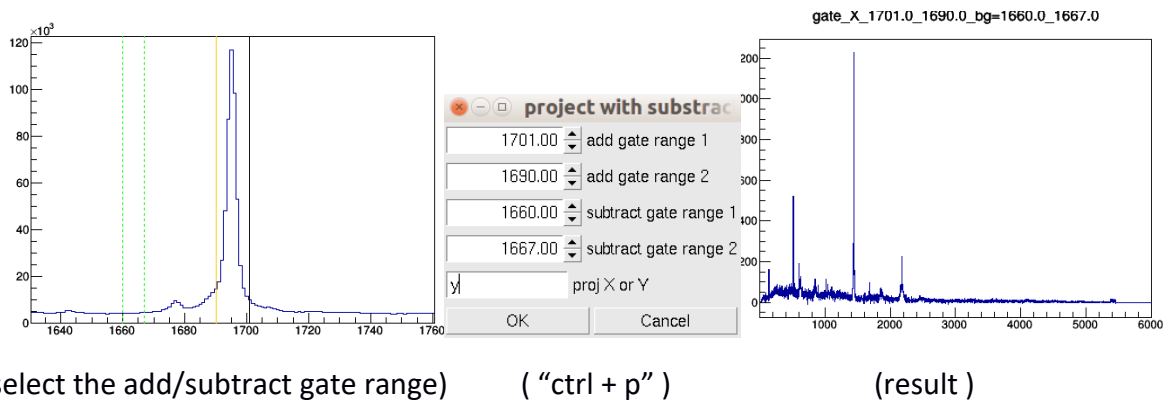
(1) select the add gate range by mouse right click (black and yellow line)

(2) select the subtract gate range by "ctrl+ mouse right click"

Note: the order (1) and (2) can be switched.

(4) press " ctrl + p"

(5) type in "x" for projecting on the x axis / "y" for the y axis.

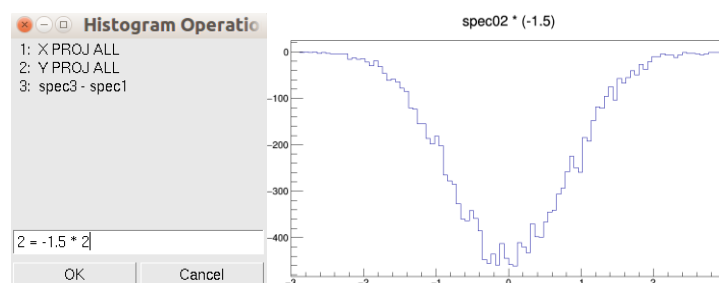


15 Histogram operations

Hotkeys: ctrl+c, V, alt+r

To remove a histogram in our histogram pool. First, click the pad which displays the histogram you want to delete. Then press "ctrl+c", and then the histogram will be gone. The pad you clicked will display the first hitstogram in our histogram pool. When only one histogram left, then the "ctrl+c" will be disabled.

After pressing "V" key, there will be a dialogue for histogram operations. Here you can do some simple histogram operations, such as addition, subtraction, multiplying a constant, and making a copy.

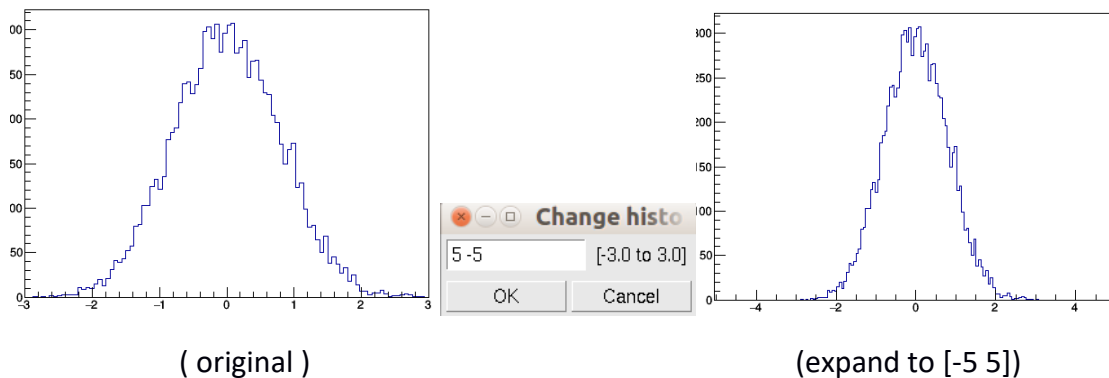


After pressing “V” key, there will be a dialogue for histogram operations. Here you can do some simple histogram operations, such as addition, subtraction, multiplying by a constant, and making a copy.

Operation Rules

- (1) ex. "99 = 1 + 2" means $h_{new} = h_1 + h_2$ when we just have two histograms. A new histogram will be created when the number to the left of the equal sign is larger than the number of our total histograms.
- (2) " 1 = 1 + 2" means $h_1 = h_1 + h_2$.
- (3) "1 = -1.5 * 2" means $h_1 = -1.5 * h_2$. when multiplying by a constant, the constant's position is fixed at the second number.
- (4) "99 = 1" means $h_{new} = h_1$. To make a new copy, use just one equal sign.
- (5) "99 += * " means $h_{new} = h_1 + h_2 + h_3 \dots$ It adds up all the histograms.
- (6) "99 += 1..3" means $h_{new} = h_1 + h_2 + h_3$ (use two dots as the separator.)
- (7) "del 1..3" means to delete h_1, h_2 , and h_3 .

“alt+r” allows you to change the range of a histogram by truncation or expansion while keeping the same bin width. For example, the original range is [-3 to 3], you can expand to [-5 to 5] or you can truncate it to [-1 to 1].



16 Changing title and styles

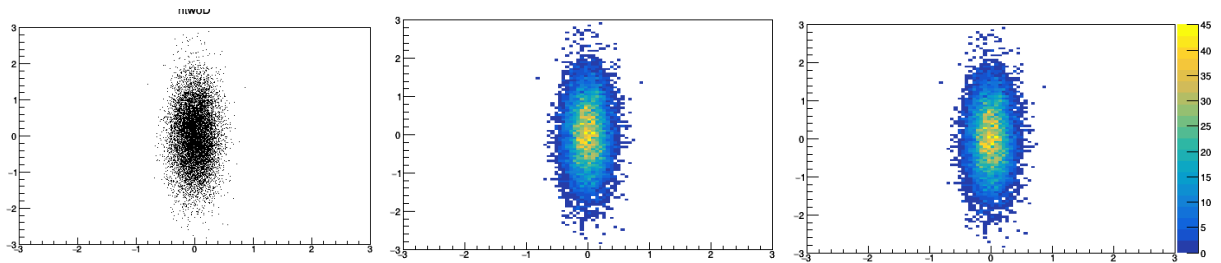
Hotkeys: ctrl+t, F1, F2, F3

“ctrl + t” is to change the title of a histogram. If you have set up other attributes like axis titles by root default context menu, it will also back it up, so that will you apply rebin/Undo rebin, the axis labels are still there.

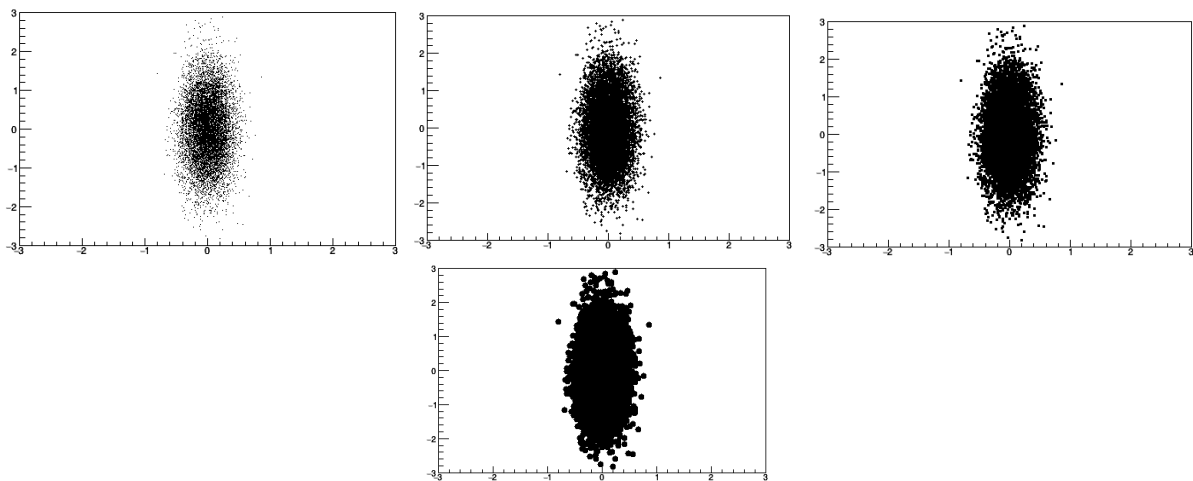


For a 2d histogram styles:

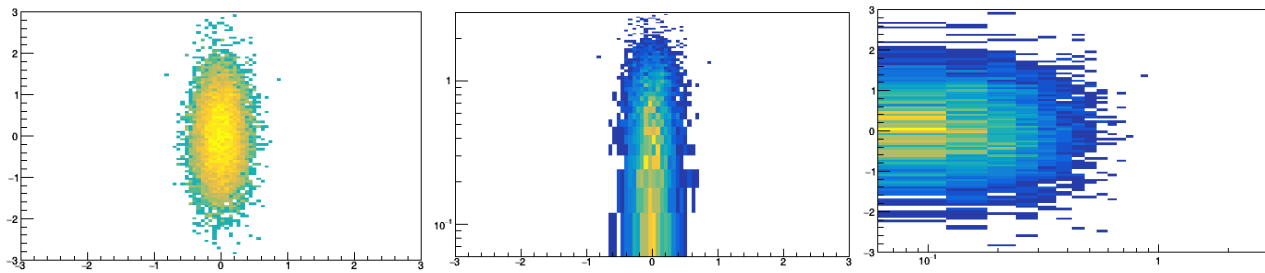
“F1” key will switch among Draw(), Draw(“col”), Draw(“colz”)



“F2” key will switch among 4 different marker sizes.

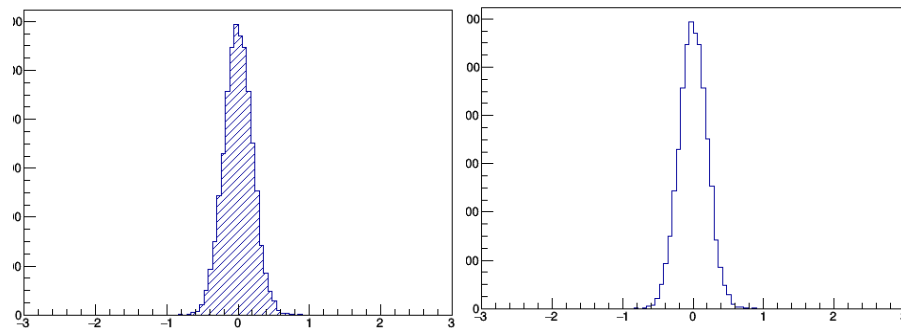


“F3” will switch setting the log scale among x, y, z axis, and none.

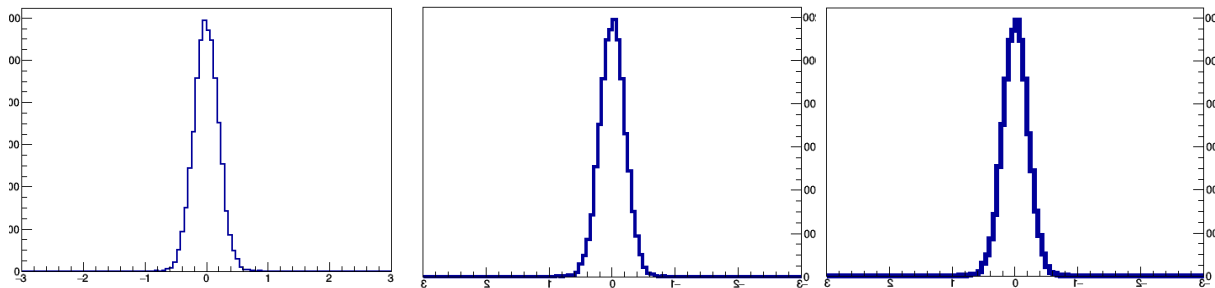


For 1d histogram style:

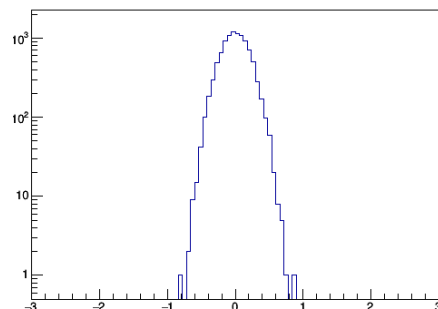
“F1” key will turn on or off the filling.



“F2” key will switch the 7 different line width.



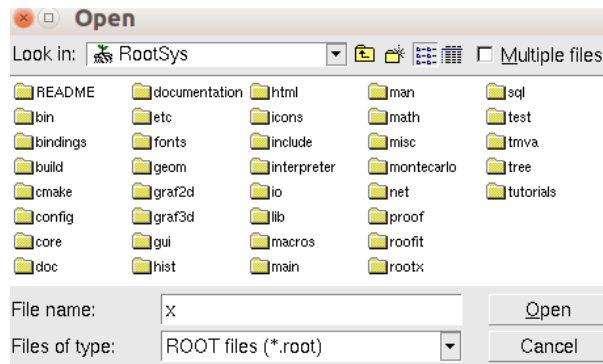
“F3” key will turn on or off the log scale on the y axis. Note: in the log scale mode, the marker lines display will be wired. Please bear with it, because I haven’t figure out how to convert NDC coordinates to the coordinates in the pad.



17 Write out or read in root files.

Hotkeys: ctrl+w, ctrl+r

“ctrl+w” to write out to a root file containing our 1d/2d histograms. The “.root” extension will be automatically attachment if the ending is not “.root”. If your input is “x” for the output filename, then it will use the hitsogram’s title as the root filename.



“ctrl+r” is for reading in a root file.

We will append all the 1d histograms in the file, but update the current 2d histogram so that we just has a single 2d histogram.

18 ROOTSCOPE Hotkey summary

d	display the histogram.
ctrl + d	overlap two histograms.
c	switch between overlap mode and normal display mode (2 histograms)
f	finding peaks.
V	perform simple histogram operations.
ctrl + c	delete the histogram in the selected pad.
alt + r	change the x range of a 1d histogram (keep the same bin width).
q /ctrl + q	display the 2d histogram/ go back to the 1d histogram(s) display
mouse left click	set a marker line at a 1d histogram(s).
m	set a marker line at a 1d histogram(s).
alt + m	input a specific value for the position of a marker line.
ctrl + mouse left click	set an auxiliary marker line at a 1d histogram.
ctrl + mouse left click	set a set of marker lines at a 2d histogram.
n	clear all the maker lines/text labels/etc...
e	expand a 1d/2d histogram at a given range.
E	expand a 1d histogram by specific user input values.
o	undo expansion for 1d/2d histogram
arrow key left/right	change the x range of 1d histogram(s) in display.
arrow key up/down	switch the histogram.

y	set the max user y value for a 1d histogram.
z/Z	set the max/min user z value for a 2d histogram.
x/X	rebin/ undo rebin the x axis of a 1/2d histogram.
y/Y	rebin/ undo rebin the y axis of a 2d histogram.
alt+r	truncate or expand a 1d histogram by keeping the same bin width.
b	fit a given range for a constant background value.
alt + b	input a specific value for the constant background value.
l	fit a given range for constant and slope terms of pol1 for background.
g	fit a given range for background + one Gaussian function.
G	fit a given range for background + double Gaussian functions.
s	get the sum for a given range.
f	find peaks
ctrl+f	control the parameters used in peak-finding function.
p	gating on x and project on y.
P	gating on y and project on x.
ctrl + p	add-subtract gate projection.
F1	switch the color/BW display of a 2d histogram.
F2	switch the marker size of a 2d histogram.
F3	switch the log scale setting to x, y, z axis.
F1	Turn on or off the filling for a histogram.

F2	switch the line width for a 1d histogram.
F3	Turn on or off the log scale for the y axis for a 1d histogram.
ctrl + r	to read in a root file; append 1d histogram, but overwrite 2d one.
ctrl + w	to write out a root file containing current 1d/2d histograms.

19 ROOTSCOPE_lite Hotkey

f	finding peaks.
alt + r	change the x range of a 1d histogram (keep the same bin width).
mouse left click	set a marker line at a 1d histogram(s).
m	set a marker line at a 1d histogram(s).
alt + m	input a specific value for the position of a marker line.
ctrl + mouse left click	set an auxiliary marker line at a 1d histogram.
ctrl + mouse left click	set a set of marker lines at a 2d histogram.
n	clear all the maker lines/text labels/etc...
e	expand a 1d/2d histogram at a given range.
E	expand a 1d histogram by specific user input values.
o	undo expansion for 1d/2d histogram
y	set the max user y value for a 1d histogram.
x/X	rebin/ undo rebin the x axis of a 1d histogram.
alt+r	truncate or expand a 1d histogram by keeping the same bin width.

b	fit a given range for a constant background value.
alt + b	input a specific value for the constant background value.
l	fit a given range for constant and slope terms of pol1 for background.
g	fit a given range for background + one Gaussian function.
G	fit a given range for background + double Gaussian functions.
s	get the sum for a given range.
f	find peaks
ctrl+f	control the parameters used in peak-finding function.
F1	Turn on or off the filling for a histogram.
F2	switch the line width for a 1d histogram.
F3	Turn on or off the log scale for the y axis for a 1d histogram.
ctrl + w	to write out a root file containing current 1d/2d histograms.