Getting Started with ROOT

Welcome to Getting Started with ROOT. Physicists are involved in the business of getting data into files, analyzing it, and then producing histogram plots and fits. This tutorial is aimed to the novice ROOT user as the tool for doing this. Hopefully it will get you into using ROOT quickly even if you have little to no knowledge of C++, the language of ROOT commands.

Getting Started with ROOT has 4 parts:

- First ROOT Session Step by Step
- Using the ROOT Browser and Graphical Interface
- ROOT Commands
- Further Documentation about ROOT

To begin, we will provide you with a sample ntuple file to use with ROOT's graphical interface that will take you step-by-step through your first ROOT session. You will manipulate the ntuple by using the ROOT Browser, where just by clicking you can display histograms, save and print them. You can interact with the canvas to modify objects that are in the display and also create new graphical objects. Using the mouse buttons you are able to set up different views of histograms and make fits to them.

Part 2 covers ROOT's graphical interface in greater depth and points out some features that were not covered in the first step-by-step tutorial.

Although there are many things to do in ROOT without even typing in a command, once you've had some fun and experience with ROOT's graphical user interface, we hope you will be interested in going to the next step - using root commands as well as the GUI during ROOT interactive sessions. Part 3 - ROOT COMMANDS deals with this. These commands are equivalent to what you will have done using the graphic interface in the step by step session with additional commands to provide more flexibility for drawing histograms with cuts or using functions. You'll want to be working in ROOT with some ntuple files that you are familiar with, so if you were working with ntuples using PAW we'll show you how to convert those files into ROOT and if you have an ASCII file, we'll show you how to read the file and make an ntuple from it.

After you are acquainted with root commands the next step is writing ROOT macros. For that stage we will point you towards further documentation about ROOT for the more advanced user and places which have examples of macros that you can use for macro templates.

Now let's get started.

Part 1 : First ROOT Session Step-by-Step

What are we going to do? Start an interactive ROOT session. If you need to set up ROOT click here. Although we've stated that this part is ROOT command free, we will give you one command that you just have to copy. The command is to bring up the ROOT Browser on your screen. Then you will use the Browser and your mouse to see some of the fun things that you can do. These include graphical manipulations such as color, font, text ,etc and fitting and drawing procedures for histograms (lego plots, surface views, etc).

Step1: Start an interactive root session

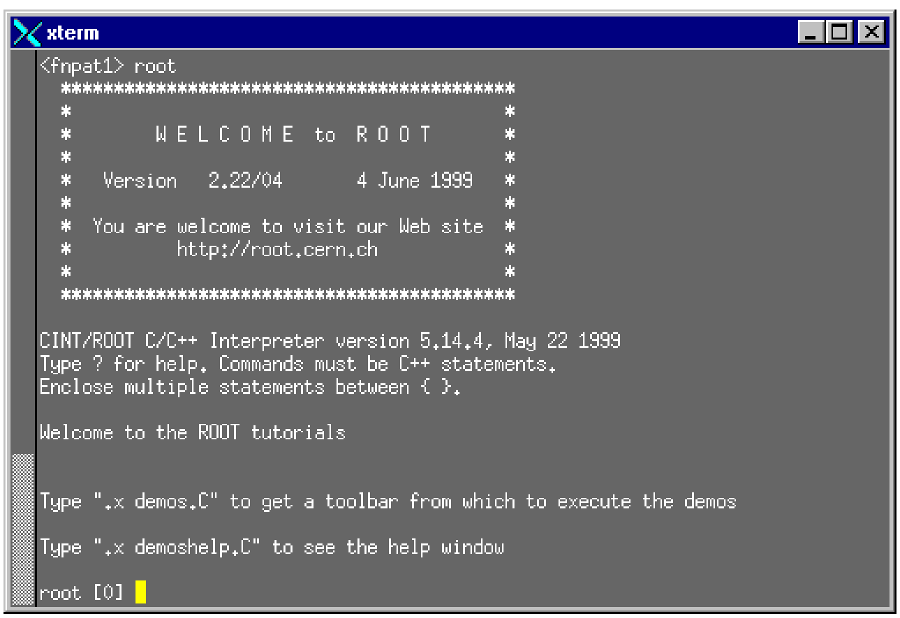
The first thing we need is the sample file. Click here http://fnpspa.fnal.gov/root/101/htt_175a.root and copy the file htt_175a.root to your $HOME (or ~) directory.

Now we can get started. From your $HOME directory start root by typing at system prompt

(>) **root**

A root screen will appear. This is the screen for entering commands.

The 'root prompt' line is where you enter the commands. It starts with the word "root", followed by a number in brackets. The number in brackets is the number of commands that you have entered so far (at this point: root [0]).



Before we start, it's a good idea to mention how to end a root session.

You end a ROOT session by typing **.q** at the root prompt line.

Step 2: Bring up the ROOT Browser

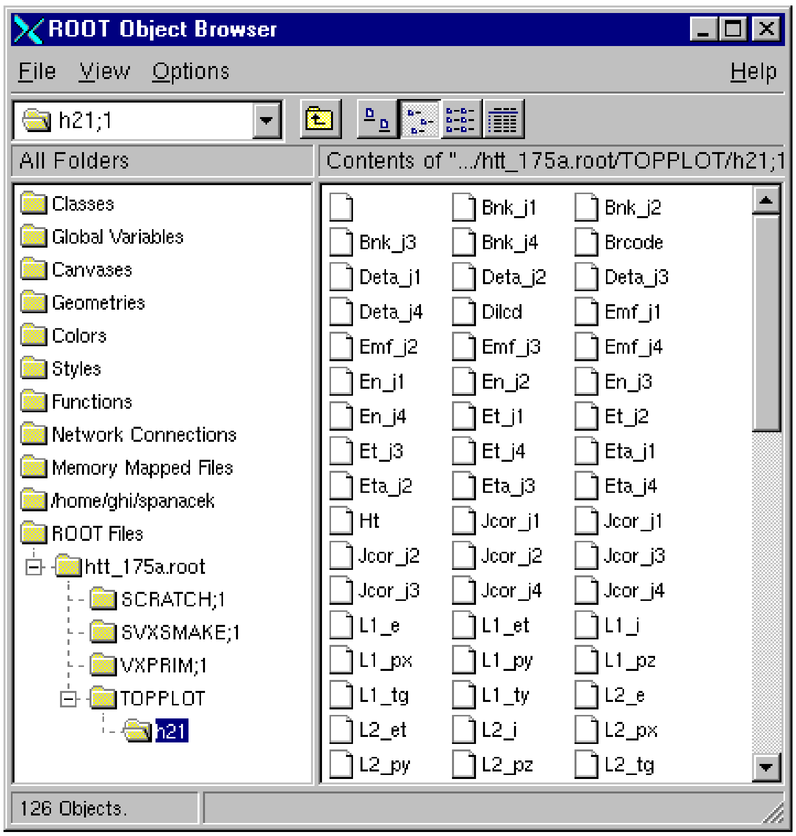
At root [0] prompt line type: **b = new TBrowser();**

A separate window will appear on your screen with the ROOT Browser

The browser lists everything that is part of the current ROOT session.

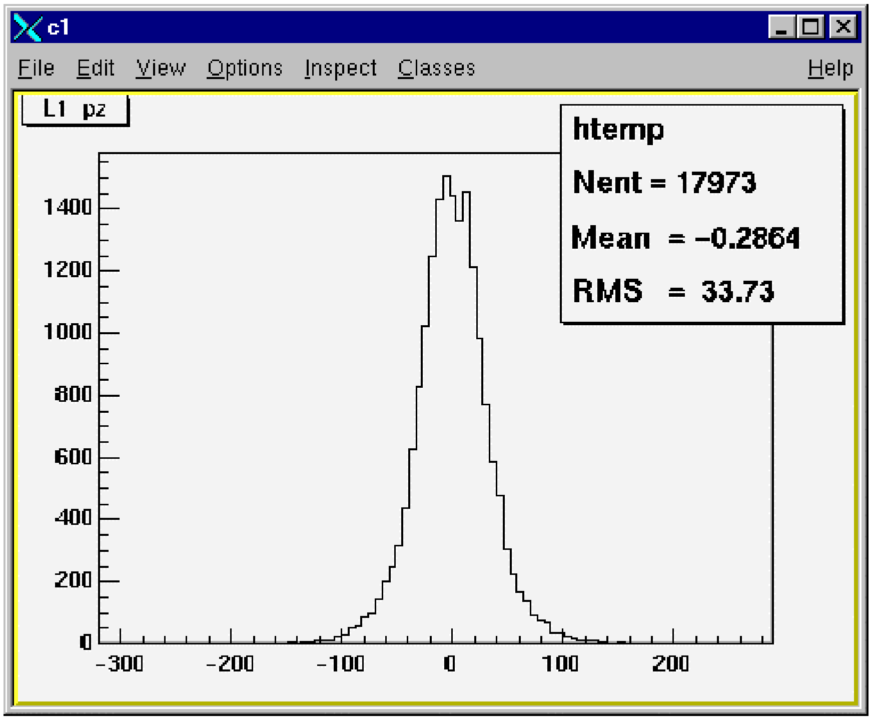
Open the root file which has the sample ntuples that we will be using in this example.

In the browser window select the Open menu item in the File menu. Click on the file htt_175a.root and click on the Open button



Get to our sample ntuple via the ROOT Browser

- Double click on the **ROOT Files** folder. Beneath it, the name of the root file which we just opened will appear
- Double click on the folder next to the file name: **htt_175a.root** . Another list of folders will appear beneath it.
- Double click on the **TOPPLOT** folder. A folder called h21 appears beneath it. "h21" is actually a ROOT Tree which contains our sample ntuple variables.
- Double click on **h21**. A list of the variables that are in that file will appear on the right hand side of the screen. Now your browser should look as shown.
- Double click on the variable **L1_pz** that appears on the right hand side of the screen. ROOT will automatically generate and display a 1-D histogram of that variable.



The histogram display should look like this.

Step 3: Manipulating the ROOT Canvas

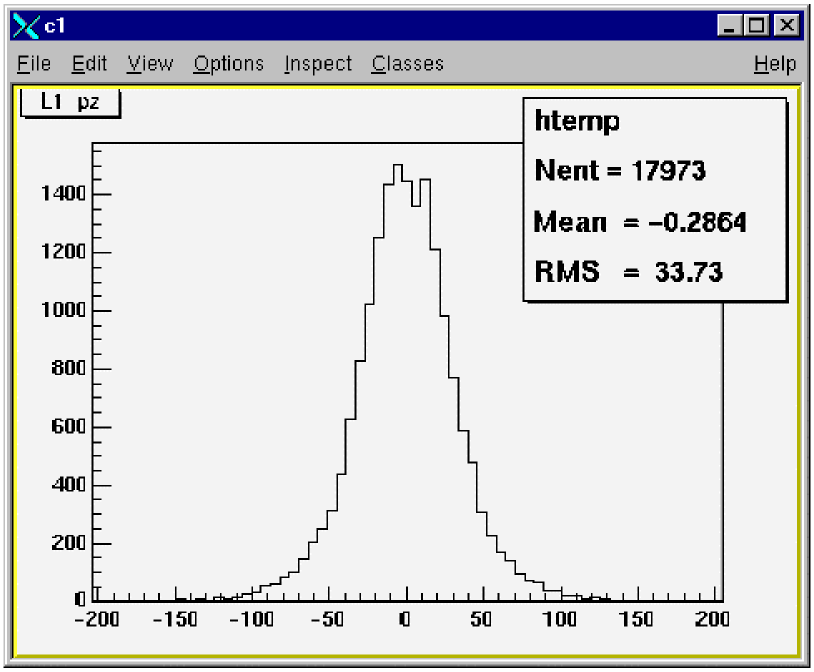
What you are looking at above is a ROOT canvas. The canvas is the area of the window where you can interact with the ROOT objects. ROOT automatically generated the canvas. It named the canvas **c1** and displayed the variable **L1_pz** that we double clicked on from the ROOT browser. There are many things that you can do to modify the canvas. We'll just try a few during this first session:

Display the Event Status: Before we start selecting objects on the canvas, let's look at an example of the event status bar. It helps you see what you are

selecting.

To display this, you select the **Event Status** item from the **Options** menu of your canvas. The Event Status bar appears at the bottom of the window. You can use it to get the status of the object that you pick e.g. for the histogram it gives information about the name of the histogram, the position of x and y in coordinates and the channel no. and content. If you are working interactively and later want to write a macro you can use this information in your macro.

Dragging and Resizing the Canvas or Objects on the Canvas: Like any other standard window you can move, stretch or shrink the whole ROOT window or an object in the canvas by pointing, clicking and dragging with the left-hand mouse button. Point to the object you want . When pointed to a sensitive area of the object the cursor will change shape. When the cursor appears as an arrow with a line it indicates the directions in which you can resize the object . A bold cross indicates that you can move the object. You can also modify the end points of a line. For an example we will modify the end points of the x-axis to display only from -200 to 200.



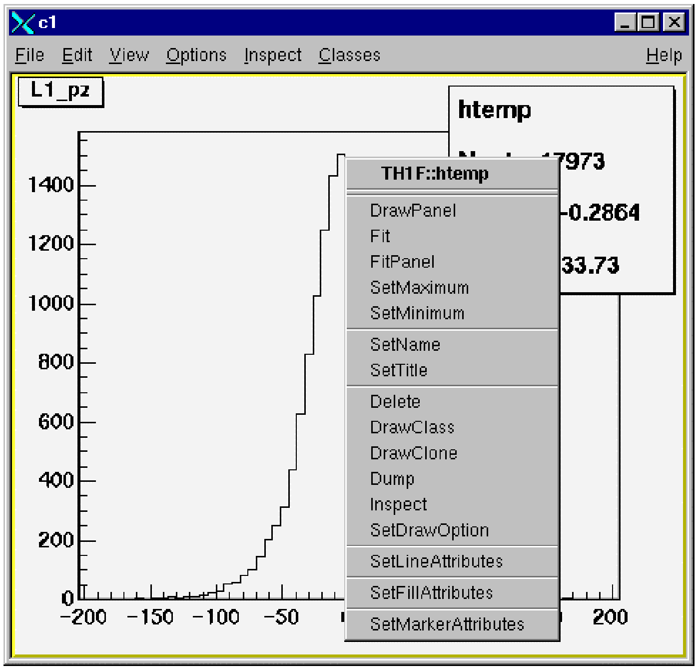
1. Point your mouse at the minus 200 point of the x-axis line. The cursor shape should change to a hand.

2. Click left mouse button and hold. A line appears as soon as you drag it little. Drag the mouse across the x-axis until the 200 point on the x-axis. Release the left mouse button. You should immediately see the new range of the x-axis displayed on your canvas. If you don't, click on the "Refresh" option which is under the " Options" menu of your canvas menu. Your canvas should now look like this:

Right now we have only one canvas, c1, and that is the active canvas. In ROOT you can create and display many canvases on the screen at the same time. The canvas that is active is the one that is color highlighted around its edges. Any action that you tell ROOT to perform interactively is done on the active canvas. Clicking on the canvas with the middle mouse button (or right and left mouse button together) makes the canvas active . For now, we will continue to use only one canvas, but later we will create another canvas and use it to display more than one histogram on the same canvas.

Step 4: Using Context Menus to change attributes of objects

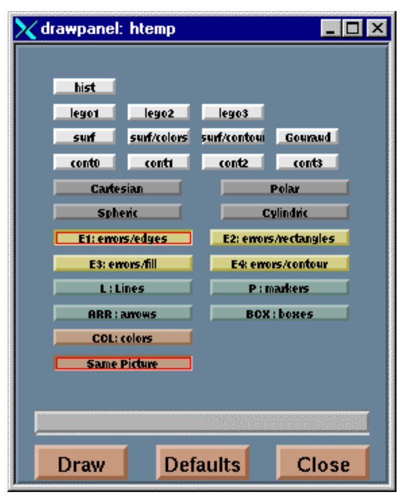
When the right mouse button is clicked on any object in a canvas, a context menu will pop up on the screen. This menu is a list of options that are specific to the object you clicked on. Let's try it by using the histogram object.

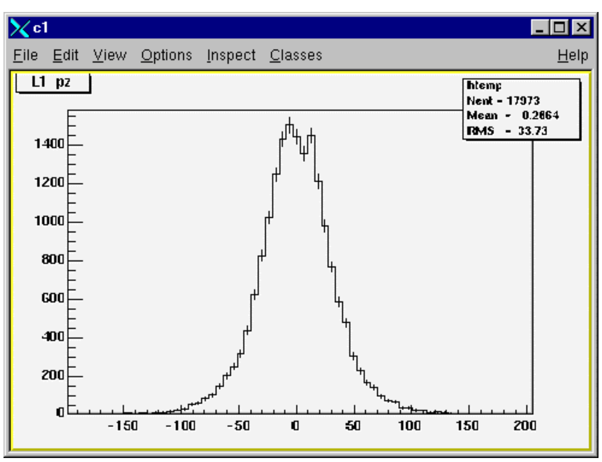


Click your right mouse button over any horizontal point on the outline of the histogram. You will notice the cursor changing to an arrow when the histogram is selected. A context box should appear with the title TH1F::htemp. Move the mouse to the Properties" option and a list of properties appears beside it. It should look like this.

There are two special options for histograms that appear in this list. One is **DrawPanel**. It brings up another window that gives you options for the way the histogram is drawn and displayed. It includes the standard histogram view as well as various lego views, and additionally, contour plots and surface views. The other option panel for histograms is **FitPanel.** You can choose different ways for performing the fit.

Move the mouse to the **DrawPanel** option and let go. Left mouse click on the **Same Picture** box and the **E1:errrors/edges** box. Then click on the **Draw** button .

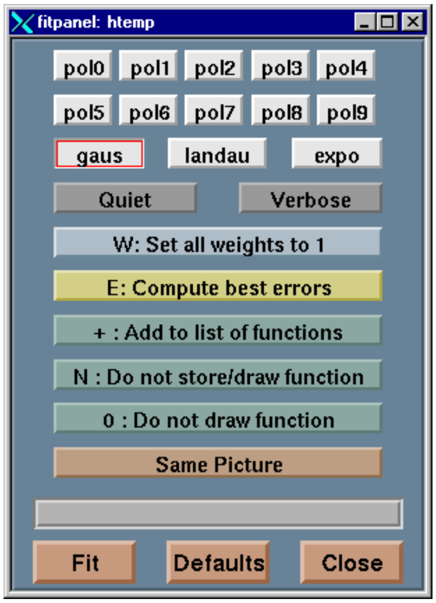




We won’t be using the error bar display right now, so we’ll reset the histogram view back to the standard histogram view. To do this, click on the **Defaults** button and then the **Draw** button.

Now we'll use the FitPanel option

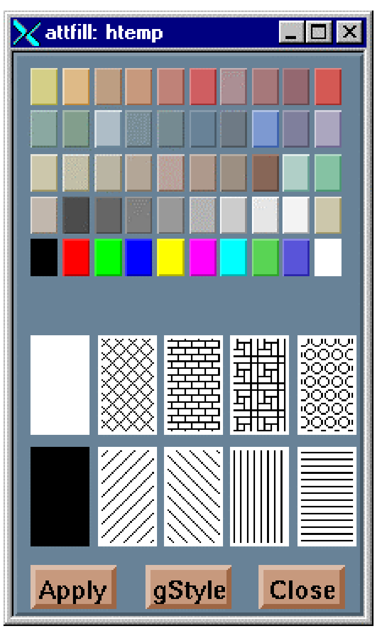
Click your left mouse button on the FitPanel option. The FitPanel window appears

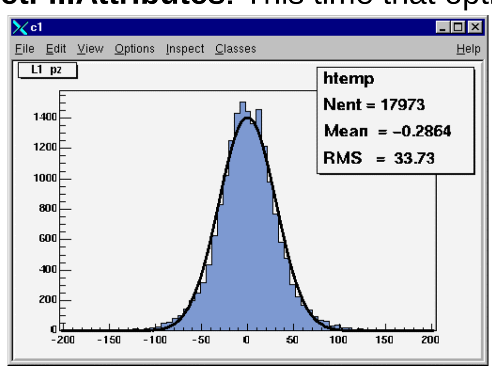


Click on **Verbose** to have all the fit information appear on your Root command screen when the fit is executed. Click on gaus and then click the Fit button. The fit is displayed on the canvas. (If the fit doesn't immediately display, it should do so by clicking on the "Refresh" option that is under the canvas menu item "Options".)

Now we'll set the fill color

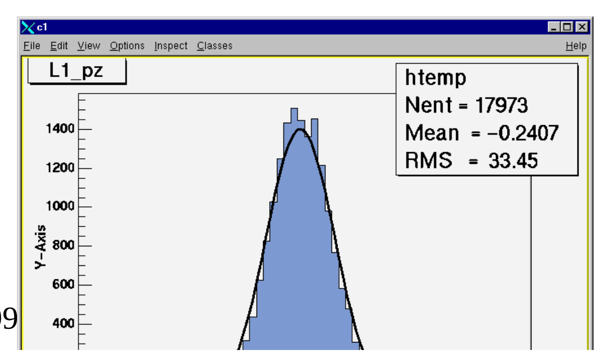
Go back to any horizontal part on the outline of the histogram to bring up the histogram context menu again. Click on **SetFillAttributes**. This time that option panel





appears. Choose a color and click on the Apply button. Your histogram will be filled with that color and look as shown.

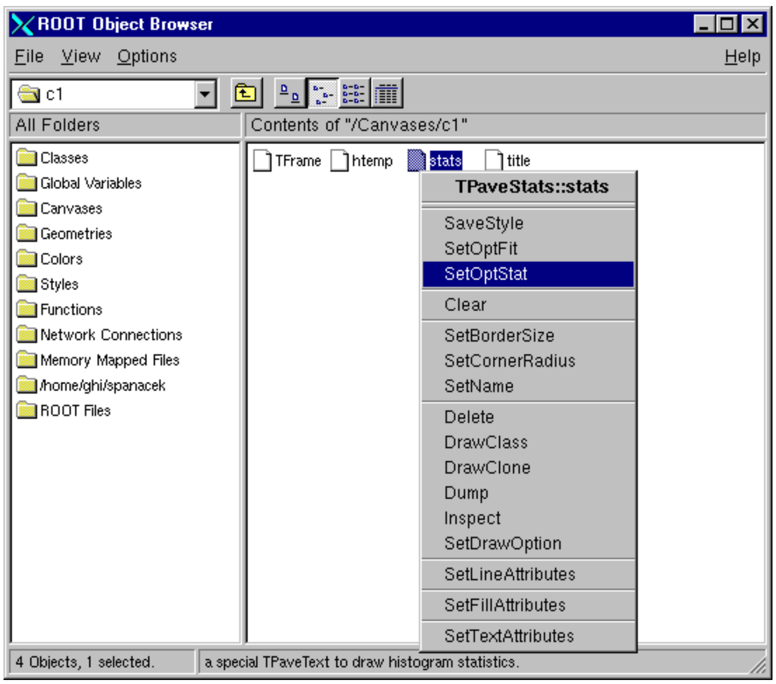
You can also use the context menu of the axis to give it a title. To do this right click on the x-axis. This brings up the



context menu. Select **SetTitle** and type X-Axis in the text box and click OK. You will see the title appears, but it is all the way on the right side of the axis. To center it, bring up the context menu of the x-axis again by right clicking on the x-axis. Select **CenterTitle**. The text box will display kTrue, and that is what you want. Just select OK, and the title is now centered. You can add the title to the y-axis by repeating this procedure on the y-axis.

Your histogram should look like this:

Another way to get to the context menus of objects on the canvas is to use the ROOT Browser. We'll use it now to modify the statistics so that it displays overflow and underflow values.



Bring up a new browser window by choosing the **Start Browser** item that is under the "Inspect" menu in the canvas window. Double click on the **Canvases** folder. A folder for canvas **c1** will appear beneath it. Double click on **c1** and a list of objects that are in that canvas appear on the right hand side of the screen. Right mouse click on **stats** to bring up the context menu for it. Left mouse click on the option **SetOptStat**. A dialog box will appear and you enter **111111** (This is a PAW convention used for setting all statistics on.) Again, use the "Refresh" option under canvas menu item " Options", if the change isn't immediately displayed. You can resize the statistics box to make it more readable on the canvas.

<u>Step 5: Using the ROOT website Class and Members Reference</u>

Right now, with the above example on hand, is a good opportunity to just introduce the ideas of classes and objects that ROOT uses. **TPaveStats::stats** is the header of the context menu which appeared when we right clicked on the statistics box. What this means is that this object which we clicked on, is an object of the **TPaveStats** class. In order to find out about it, we are going to look up the TPaveStats class via the "Classes and Members Reference" index that the ROOT web site provides. Each class used in ROOT is listed in the index with a description of the class with its options. The location for the Class Index is:

http://root.cern.ch/root/html/ClassIndex.html

Go to TPaveStats in the index and click on it. The window for TPaveStats appears. Click on class description and it will take you to a description of the class with all of its options. Here is where you can find out what it means to set the options to (111111), just as we did in the step by step session.

Making use of the index is a very good way to become familiar with ROOT classes and their uses.

Step 6: Using the Editor from the ROOT drop down canvas menu

The ROOT canvas menu has menus for File, Edit, View, Options, Inspect and Classes. We've already mentioned the options Refresh and Event Status that appear under the Option menu. For the next step in our first session we are going to make use of the **Editor,** an option under the Edit menu, which brings up a canvas dialog screen. This screen allows you to interactively create new graphical objects on the screen.

1. Bring up the Editor by clicking on the **Editor** option located in the **Edit** drop down menu on the canvas. Click on the **Arrow** button. Go to your canvas c1 and place your mouse at the point that you want to begin the arrow. Click left button and keeping it pressed, drag to the end point of the arrow. Release the mouse button to set the arrow in the canvas.

2. Click on the **Text** button. Click the left mouse button at the point in the canvas where you want to put the text. Type in the text and then press carriage return. If you want to move the text to another place on the canvas, you can point to the text while keeping the left mouse button pressed and then drag the text to a new position on the canvas.

3. If you want to delete an object, right mouse click on the object and then choose Delete from the context menu. When the dialog box appears, leave it empty and click OK.

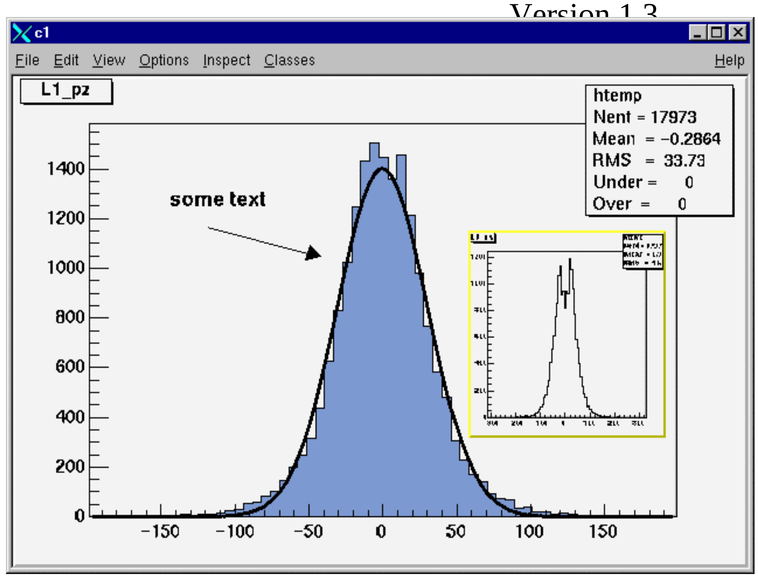
4. Click on the **Pad** button. This allows you to make a pad (a sort of mini-canvas) within the canvas. Just as above, click the left mouse button at the point where you want to place the pad on the canvas. Keeping the button pressed, drag your mouse across to draw the size of the pad you want. Release the left mouse button to set the pad in place.

5. Now you can draw another histogram in the new pad you've created. First you have to make sure that the pad is active. It should be highlighted with a colored line around it. If it isn't you can make the pad active by clicking on it with the middle mouse button. Then go to the ROOT Browser screen that has the list of variables.

6. Double click on the variable that you want to display in the pad (I've double clicked on L1_py). It should appear in the pad within the

canvas.

7. If you wanted to print the canvas, you click on **Print** under the canvas menu option **File.** Root saves the file as a postscript file that you can print later. The file is saved in the current directory as c1.ps.

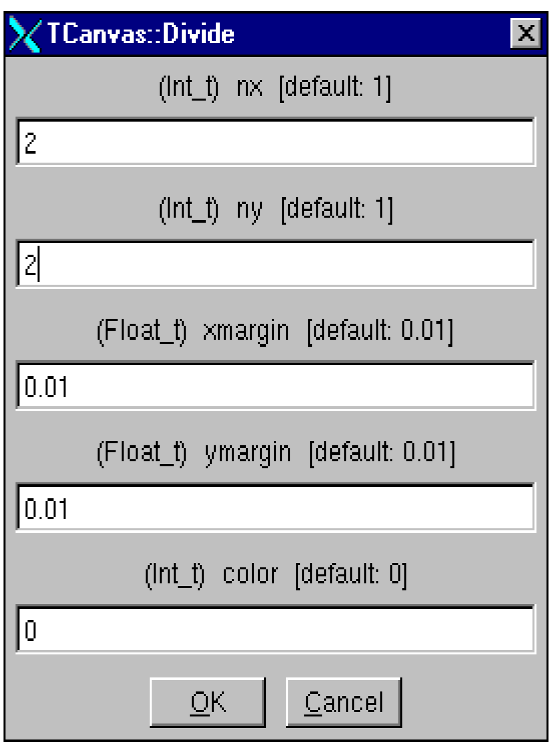


ROOT has a full explanation of **How to Use the graphics Editor** located at:

http://root.cern.ch/root/HowtoEdit.html

Step 7: Making a new canvas which displays more than one histogram

1. Click on the **New Canvas** option on the **File** canvas menu of canvas c1. A new canvas is automatically created that is named **c1_n2**. This new canvas should now be color highlighted around its edges to indicate that it is the active canvas. If is isn't, click on the canvas with the middle mouse button (or right and left together) to make it active.



2. Point the mouse within the empty canvas and right mouse click to bring up the context menu screen for the canvas. Click on the property **Divide**. A box should pop up which looks like this. To make a canvas with four pads, you enter the options as shown and click on OK.

Now you have an empty canvas with 4 pads in the display. We'll use the 4 pads to set up four different displays of the variable L1_px.

To do this:

1. Click on the upper left pad with the

middle mouse button to make it the active pad. This will be our pad that displays the standard histogram view. Then go to the root browser showing the list of variables and double click on the variable L1_px.

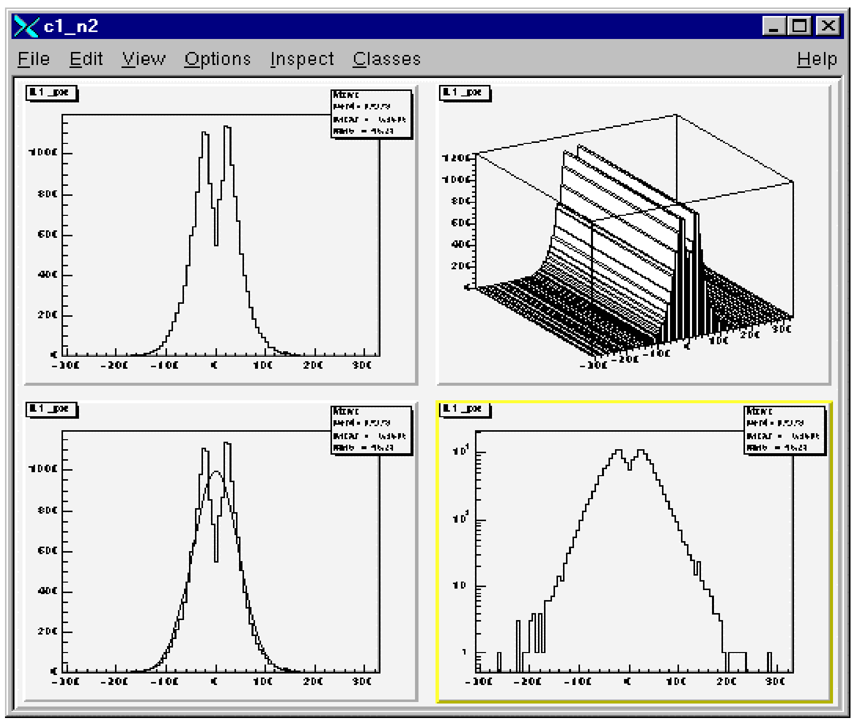
2. Click on the upper right pad with middle mouse button to make it active. Then, just as above, go to root browser and double click on the variable L1_px again. Go to the outline of the histogram and right mouse click to bring up the context menu for this pad's histogram. From the Properties list, choose **DrawPanel**. In the DrawPanel window, click on **lego1** and then **Draw**. When you have a lego plot like this you can use the left mouse and rotate it. Press down on the left mouse button and drag it. You can see the transparent cube moving with the mouse. Let go, and the plot is drawn with the new perspective.

3. As above, click on the lower left canvas pad with middle mouse button to make it active and then fill it with the variable L1_px. Right mouse click on the histogram outline and choose the **FitPanel** option from the Properties list. In the FitPanel window, click **gaus**, **set all weights to 1**, and then **Fit**.

4. Make lower right canvas pad active and fill with variable L1_px. This time, point your mouse in the outer canvas part of the pad to bring up the canvas context menu for that display. Click on **SetLogy.** The pad will display a logarithmic view of the variable.

5. Again, you can print the canvas display by clicking on Print from the File item menu on the canvas. It saves the canvas as a postscript file that you can print later.

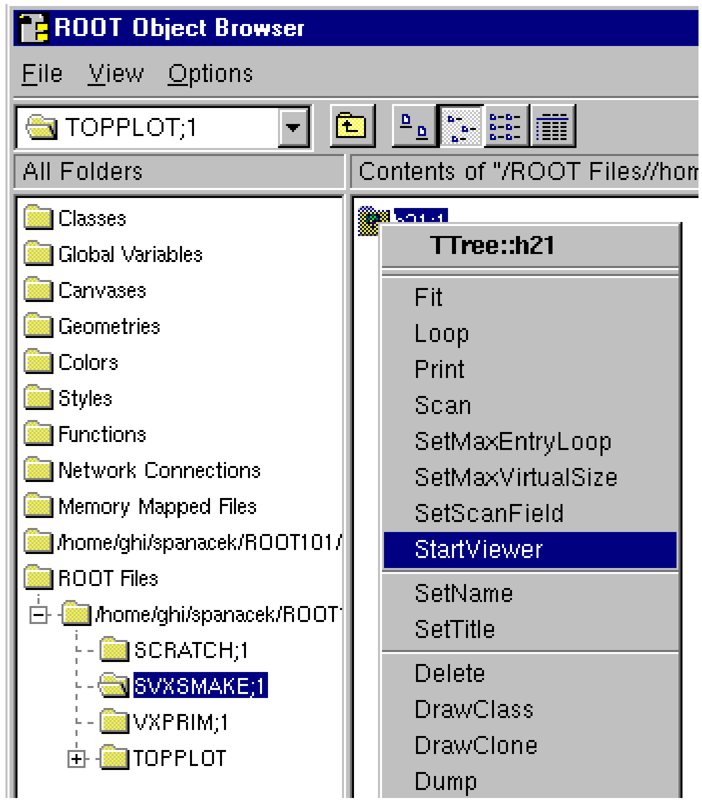
We've finished setting up 4 pads on the canvas with 4 views of the L1_px variable and it should look like this.



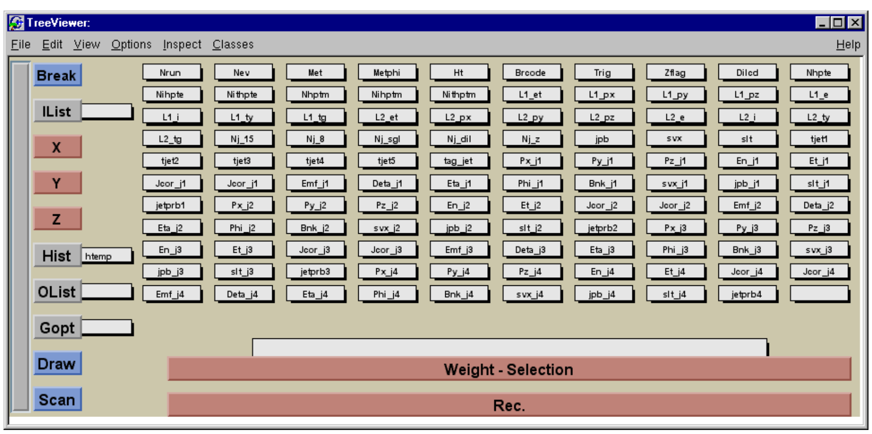
Step 8: Using the Tree Viewer

Root introduces a new concept of organizing and storing data that it calls Trees. Without getting too involved in the nitty-gritty of this concept, the Tree architecture extends the concept of the Ntuple to all complex objects or data structures found in Raw Data tapes and DST's. The idea is that the same data model, same language, same style of queries can be used to all data sets in one experiment.

The tree viewer is similar to the ROOT Browser. It brings up a separate canvas on the screen that allows you to look at the contents of a tree. To bring up a tree viewer for our ntuple file " h21", locate the h21 tree in the browser and right-click on it. Select "Start Viewer".



You will be prompted to enter the size of the viewer, at this time just click OK, you will be able to resize it later. Now the tree viewer is appears. You will need to resize it to see the entire viewer.



All of the variables in the tree are represented by TPaveVar objects. These are the white boxes with the text on the viewer.

The set of buttons on the left of the canvas allow you to perform the following operations:

Button	What does it do?
Draw	Display the active variable(s) that are placed in the X, Y, Z buttons

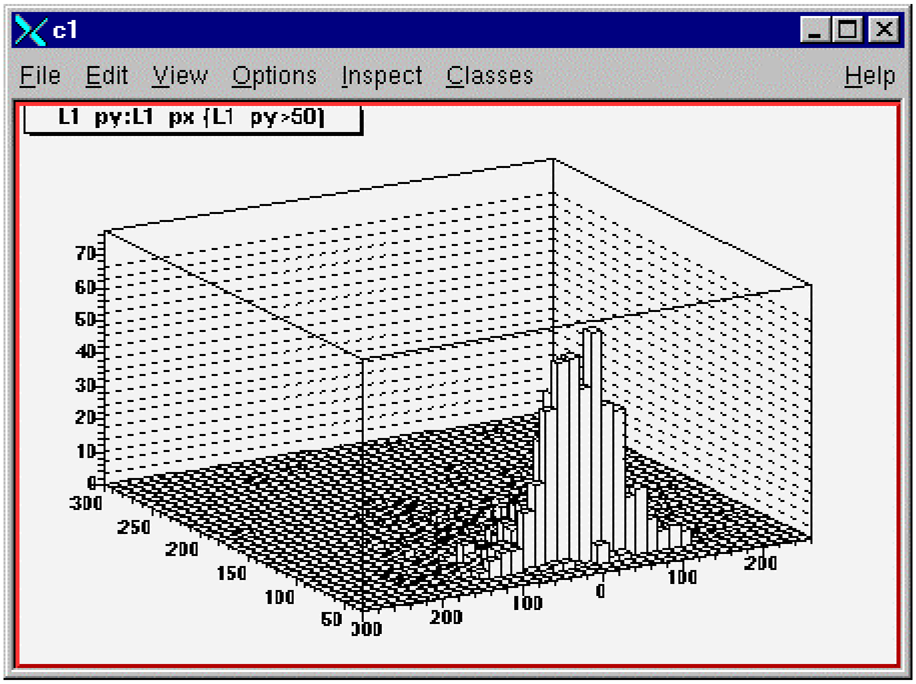
Scan	Same with TTree::Scan output style (not for beginners)
Break	Interrupt the current event loop
OList	Creates a new TEventList using the current selection
IList	Actives a TEventList as an input selection
Hist	Redefines the default histogram (default = htemp)
Cpad	Specifies the output pad (default = c1)
Gopt	Used to specify graphic options
X	To select the X variable
Y	To select the Y variable
Z	To select the Z variable
Weight-Selection	To select the weight/Selection expression
Rec.	Record the command in the history file.

In addition, the **vertical slider** on the left-hand side of the canvas can be used to select the **minimum and maximum events range.**

Now let's use it to set up a 2 dimensional lego view of L1_px and L1_py with a selection cut of L1_py >50.

To do this:

- Left mouse click on **L1_px** and drag and drop it to the **X** button. Left mouse click on **L1_py** and drag and drop it to the **Y** button
- Right mouse click on the white box next to the **Gopt** button. Select the item "Set Label". An option box appears on your screen. Type in: **lego** then click "**OK**"
- Right mouse click on the white box next to the **Weight -Selection** button. Select the item "Set Label". An option box appears on your screen. Type in: **L1_py>50** and then click "**OK**"
- Click on the **Draw** button



When the "Draw" button is clicked, The TTreeViewer object assembles the information you've set up and draws the event with the corresponding arguments. While the event loop is executing, a red box inside the slider bar indicates the progress in the loop.

While the "Draw" button is executed, the event loop can be interrupted by clicking the "**Break**" button. The current status of the histogram is shown.

All variables can be dragged and dropped to their destination (which can be X, Y, Z or Weight/Selection).

You can create a new variable by clicking with the right mouse button on the TTree viewer canvas and selecting "**CreateNewVar**". When the option box appears, create your variable. For example: L1_py**2+L1_px**2

The variable is created (it is sometimes hard to find, look at upper left corner of screen just a bit above the Break box). If you click on draw (or double-click on the TPaveVar itself) a new canvas will be drawn which will have all of your current setup for events range, cuts, graphics option and weights-selections option.

At any time the canvas history can be saved in a Root file via the standard tool bar menu "File" and item "Save as Canvas.root". If the current canvas is called c1, it will generate a file c1.root. You can continue a previous session via

```
Root > TFile f("c1.root");

Root > c1.Draw();
```

Step 9: Ending the ROOT Session

To end the root session, at the root prompt line type: **.q**

We're just about to end this first step by step session, so let's review what we have done. We've touched upon many of the options that are available to you when using ROOT's graphical interface interactively with a canvas. We've used ROOT's Editor menu to create new graphical objects on a canvas. We've begun to learn about ROOT's Object Browser and have used context menus to change the graphic display and to make very basic fits and displays on the canvas. Lastly, we've used the Tree Viewer/browser. It allows you to use your mouse for the display of 2 dimensional histograms and makes many of the features of the graphical operations accessible via the TTreeViewer canvas.

Coming up is Part 2 - The ROOT Browser and Graphical Interface, where we will briefly review options that can be performed just by clicking and using your mouse, and Part 3, which deals with ROOT commands.

Part 2 : Using ROOT's Graphical Interface

We hope you enjoyed making use of the ROOT graphical interface in the step by step example. In this section we will look at it in greater depth and mention some options that were not covered in Part 1.

The Canvas Menu and its options

The ROOT canvas has a drop down menu which includes: File, Edit, View, Options, Inspect and Classes. There are also Context Menus for options

File : Most of the options for this canvas menu item are fairly self evident, but we'd particularly like to call attention to some of the **Save as** options

Option	What does it do?
Save as canvas.C	Generates a macro automatically which contain the ROOT command statements that correspond to the picture that you created interactively in canvas "c1"
Save as canvas.gif	Saves the canvas display as a .gif file
Save as canvas.ps	Saves the canvas display as a postscript file
Save as canvas.eps	Saves as an encapsulated postscript file

Edit : has options to Clear Pad and Clear Canvas. Also has option Editor

Option	What does it do?
Editor	Brings up the built-in graphics editor window which you can use to draw and edit basic primitives (arcs, arrows, text, paves, etc) starting from an empty canvas or as an

	addition to your current display A good description of how to use the editor is located at: http://root.cern.ch/root/HowtoEdit.html

View : Includes among the options:

Option	What does it do?
Colors	Brings up a separate window display of the colors available to use in ROOT with the numbers assigned to them
Markers	Brings up a separate window display of the marker types available to use in ROOT with the numbers assigned to them

Options : Includes among the options: **Show Statistics**, **Show Histogram Title**, and **Show Fit Parameters** which set the respective items to either be displayed or not displayed on the canvas. Other useful options, which we made use of in Part 1, include:

Option	What does it do?
Event Status	Displays the Event Status bar at the bottom of the canvas display window. Gives information about coordinate points on the canvas
Refresh	Refreshes the canvas display

Inspect : has 2 options

Option	What does it do?

ROOT	Brings up the Inspect window which gives information about all TROOT members being used in the current ROOT session
Start Browser	Brings up a new ROOT Browser window. Can be used by clicking to display and modify attributes of objects that are part of the current ROOT session.

Classes : has an option for Class Tree. It is more applicable for non-novice users of ROOT.

Context Menus for objects

ROOT, using the language of C++, defines an object as "an instance of class". When you click on an object in a canvas with your right mouse button a context menu appears with the name and class of the object in the title bar. Another way to get to the context menu of an object is to right click on the object from the ROOT Browser screen (via the Canvases folder). We've made use of context menus for objects by using both of these methods in the step by step session. When we clicked on the histogram within the canvas display we brought up the context menu for the TH1F histogram class. And when we clicked on the canvas "c1" via the browser we brought up the canvas (TCanvas) context menu.

Each context menu contains all of the options that are specific to that object. You can try out the different options on your own during an interactive session. Here, we'll just review some of the context menus and point out additional useful options that have not yet been discussed

Context menus covered here include: TCanvas, TH1F, TAxis, TPaveStats, TPaveText.

Options that pertain to the line, fill and text attributes of objects are available in all context menus, when applicable. These are: **SetLineAttributes**, **SetFillAttributes** and **SetTextAttributes**. They bring up special pop up menus which we have used in our tutorial that allow you to make changes to the line, fill and text display of the object very easily. Other options that are available in almost all context boxes include **Dump**, which prints the parameters of the object on your standard output, and **Inspect** which brings up a separate window that views the contents of the object selected.

The **TCanvas::** context menu contains options for the graphics canvas

Option	What does it do?
Divide	Brings up option box that allows you to divide the canvas into independent graphical pad areas
SetLogy	If you have a histogram displayed in your canvas, clicking a check on this option sets a **logarithmic display** of the y axis. Use Refresh under Options canvas menu item to see the new display
SetLogx, SetLogz	As above; to set logarithmic display on x or z.
SetGridx,SetGridy,SetGridz	Check next to the option sets the grid display on for x,y,z respectively. Use Refresh to see new display
SetTickx,SetTicky,SetTickz	Check next to option sets tick on for x,y,z respectively. Again, use Refresh to see new display

The **TH1F** context menu contains options for 1 dimensional histograms

Option	What does it do?
DrawPanel	Brings up a window with the DrawPanel to set views of histograms (lego, surf, contour) and set error bar display.
FitPanel	Brings up a window with the FitPanel box to set fits to histogram displays

Set Minimum, Set Maximum	To set limits of the display of the y-axis

The **TAxis::x axis a**nd **TAxis ::y axis** context menus contains options for the axis classes.

Option	What does it do?
SetNDivisions	To modify the number of divisions in the axis.
SetRange	To set viewing range of axis from bin first to last In order to see which bins you are interested in, make use of Event Status which is an option of the Option canvas menu
UnZoom	To reset first and last bin to full range

The **TPaveStats::** context menu contains options for the statistics

Option	What does it do?
SetOptFit	Enter "111111" for all fit options to be set on
SetOptStat	Enter "111111" to display underflows and overflows

The **TPaveText::** context menu contains options for a pave which can have several lines of text. You can create and easily place a new TPaveText object on your canvas display by using the Editor (under Edit Options).

Option	What does it do?
Insert Text	Adds new line of text at mouse position
Edit Text	Brings up an option window for modifying the color, font, size and alignment of the text.
Clear	Deletes all the pave text from display

Cursor Types

This table shows the different cursor that you may have seen and what they mean.

Option	What does it do?
Hair- line cross	Default cursor, nothing is selected
Bold cross	Object is selected (the Object can be dragged)
Arrow with a Horizontal Line on top or bottom	Expand the object towards the top or bottom.
Arrow with Vertical Line on left or right	Expand the object toward the left or right
Arrow pointing into a corner	Expand the object's size (keeping the aspect ratio)
Pointer	Ready to select a histogram, a Fit is selected, an end point of an arrow is selected.
Hand	Ready to select an axis point or function object.
Question mark	Text editing
Double line with arrows on both ends	When pointing at a text block it can enlarge the text size.
Watch	Busy
Rotating Arrows	Ready to rotate a 3-D view or a text

Part 3 : ROOT COMMANDS

In the previous sections of this document we've made use of the mouse and clicking to use ROOT's graphical interface, but now we are going to concentrate on ROOT Commands. Commands used interactively with the graphic interface give you more flexibility. Also, ROOT commands are what you put into macros, the scripts that you will later be writing in order to create, modify and display your final output. The commands are case sensitive, so make sure you've enter them properly. You don't need to use the semi-colon at the end of a command when you are working with ROOT interactively, but semi-colons are mandatory at the end of a ROOT statement in a macro.

This is what is covered in this section:

There are 3 types of commands used in ROOT. C++ syntax commands, CINT commands and SHELL commands.

C++ syntax commands are covered quite extensively in this section.

An example of this is: **root:>b =new TBrowser();**

CINT commands begin with "**.**"

A command to list all the CINT commands **root:>.?**

Load [file] and execute function [file] **root:>.X [file]**

Load [file] **root:>.L [file]**

For more information about CINT commands see:

http://root.cern.ch/root/CintCommands.html

SHELL commands start with "**.!**" For example **root:>.! ls**

Many of the commands listed in this section are the equivalent to what we did in the step by step session. Commands can easily be expanded to give greater capabilities, and the tables included below offer examples of commands for more flexible fittings and for 2-D histograms.

- **Converting a PAW ntuple file into a ROOT file**

At this point, you might want to try out ROOT using a ntuple file of your own. There is a program called **h2root** which converts files created with PAW into ".root" files that can be used with ROOT. To do the conversion, at the system prompt, you just have to type:

h2root   filename.hbook filename.root

If your file contained a HBOOK ntuple, it is automatically converted into a ROOT tree. In ROOT terms, it becomes an object of the TTree class. If your file had a HBOOK histogram, it is automatically converted into a histogram object of ROOT's TH1F class.

Once your file is converted you can start using it with ROOT.

- **Reading an ASCII file and making a ROOT ntuple**

ROOT's official homepage from CERN contains a Tutorial file, and one of the tutorials is an example of a macro that reads data from an ASCII file and creates a root file with a histogram and a ntuple. This tutorial is located at:

http://root.cern.ch/root/html/examples/basic.C.html

You can modify this macro and use it for your own ASCII files.

- **Using ROOT Commands**

At the end of Getting Started with ROOT we have a quick alphabetical index to the ROOT commands that are covered in this section.

For this example of ROOT commands, we will use the file called "htt_175a.root" that we used in First Root Session step by step. ROOT commands are entered on the ROOT Cint screen following the root prompt.

Open a file and browse it

ROOT Interactive Command	What does this command do?
.q	End a ROOT session
TFile *my = new TFile("htt_175a.root");	Open a file
TBrowser *b = new TBrowser();	Open the ROOT Object Browser
my->ls();	List contents of a file called "my"

my->cd("TOPPLOT");
 	
gDirectory->ls();
	Change directory to make TOPPLOT the current directory (the directory which contains the ntuples)
	
	List contents of current directory, now TOPPLOT

h21->Print();	To find names of variables in the ntuple file
h21->Draw("L1_pz");	To display the variable "L1_pz" as a 1-D histogram
c1->Print();	To print the display of canvas "c1". ROOT saves it as a ps file to print later.
h21->Draw("L1_pz>>myh1");	To display the variable "L1_pz" and save to a named histogram called "myh1"

If you have multiple files open you can use f1->cd() and f2->cd() to switch between the two.

Opening two files and navigating between the two.

ROOT Interactive Command	What does this command do?
.q	End a ROOT session
TFile *f1 = new TFile("htt_175a.root");	Open the first file. When opening a file it becomes the current directory. The TFile class is a subclass of TDirectory.

TFile *f2 = new TFile("Example.root");	Open a second file. Now f2 becomes the current directory. This can be any root file.
f1->cd()	Change the current directory to be f1.
f1->ls()	List the contents of f1.
f2->cd()	Change the current directory to be f2.
f2->ls()	List the contents of f2.

Here are some examples of commands for adding text to your display, setting the fill colors of objects, and the color and style of markers that are used for drawing a histogram with error bars. To see a menu of colors available to use in ROOT with the numbers assigned to them, you go to the "**Colors**" option under canvas item menu "**View**". For marker styles, you go to "**Markers**", also under canvas item menu "**View**".

ROOT Interactive Command	What does this command do?

t1 = new TPaveLabel(-235,1217,-44,1387,
"A label","br");
t1->SetFillColor(6);
myh1->Draw();
t1->Draw();
	Create a pave label
	
	Set a fill color for it
	Display canvas "myh1"
	Display the label on the canvas

myh1->SetFillColor(2); myh1->Draw();	Set the fill color of "myh1" to red and display

h21->SetMarkerColor(4);
h21->SetMarkerStyle(8);
h21->Draw("L1_py","","e1");
	Set marker color of "h21" to blue
	Set marker style of "h21" to a filled circle
	Draw "L1_py" with error bars
	(Other displays are "e2", "e3", and "e4")

Here are commands to give the **axis a title**:

ROOT Interactive Command	What does this command do?
myh1->GetXaxis()->SetTitle("X-Axis");	Give the x-axis the name "X-Axis"
myh1->GetXaxis()->CenterTitle(1);	Center the name of the x-axis.

myh1->GetYaxis()->SetTitle("Y-Axis");	Give the y-axis the name "Y-Axis"
myh1->GetYaxis()->CenterTitle(1);	Center the name of the y-axis.

Here are commands demonstrating **cuts**:

ROOT Interactive Command	What does this command do?
h21->Draw("L1_px","(L1_px>0) ");	Display "L1_px" where "L1_px" is greater than zero
h21->Draw("L1_py","(L1_px<0) ");	Display "L1_py" where "L1_px" is less than zero
h21->Draw("L1_px","(L1_py<.5) && (L1_pz>10)");	Chained cuts

These are examples of commands using **fits** and **functions.** You might need to use "Refresh" under "Options" canvas menu to display the change on the canvas.

ROOT Interactive Command	What does this command do?
gStyle->SetOptStat(111111);	Set statistics to display under and overflow
myh1->Fit("gaus");	Fit the saved histogram " myh1" with a gaussian fit.
myh1->Fit("pol9");	Fit the histogram " myh1" with a polynomial fit of degree N, in this example pol9.

f1= new TF1("f1","abs(sin(x)/x)",0,10);
 	
f1->Draw();
	Create a user-designed function and draw it

TF1 *e1 = new TF1("e1","expo",0,200);
 	
myh1->Fit("e1","R");
 	
e1->SetRange(0,200);
 	
myh1->Fit("e1","R");
	Declare a exponential function to fit over a subrange
	
	 (Note: the "R" in the Fit command stands for "range". If you leave out the "R" as an argument in the Fit command, the range of fit is the current range of the histogram(in this case, the full range)
	To reset the range to what you want, you would have to use the SetRange command:
	
	If "R" previously left out, to reset the range of fit "e1" from 0 to 200
	
	Then enter the fit command again, using "R"' option)

TF1 *g1 = new TF1("g1","gaus",-200.,200);	Display 2 subranges of fits on one display

TF1 *g2 = new TF1("g2","gaus",-200., 0);
myh1->Fit("g1","R");
myh1->Fit("g2","R+");
	using built in function gaussian function

f2 = new TF1("f2","[0]/(x*x+[1]*[1])" ,-100,100);
f2->SetParameters(1000000,30);
myh1->Fit("f2","R");
	Create a user designed function to use in a fit
	Set initial values of parameter
	Fit the function to histogram "myh1"

Commands for **creating a canvas , and pads in a canvas**

ROOT Interactive Command	What does this command do?
myc1= new TCanvas("myc1","My canvas");	Manually create a new canvas

myc1->Divide(2,2);
myc1_1->cd();
h21->Draw("L1_px>>his1");
myc1_2->cd();
his1->DrawCopy("lego1");
myc1_3->cd();
his1->Fit("gaus");
myc1_4->cd();
myc1_4->SetLogy(1);
his1->Draw();
	Automatically generate 4 pads in the new canvas "myc1" and then set the display for each pad
	Set pad1 "myc1_1" as active pad and display standard histogram view of "L1_px", saving the display as a named histogram "his1"
	Set pad2 active, and draw a copy of "his1" as lego view
	Set pad3 active , and draw a copy of "his1" with a gaussian fit
	Set pad4 active and set to display a logarithmic histogram. Display "L1_px" in it.

Commands using **global variables**

ROOT Interactive Command	What does this command do?
gEnv->Print();	Display the settings of the current ROOT environment
gObjectTable->Print();	Display list of objects known in current ROOT session
gStyle->SetOptStat(111111);	Set statistics to full display

Commands for 2 variable displays.

Here, let's just start afresh. We'll quit ROOT and start a new session where we will open our example root file and again change the directory to TOPPLOT in order to work with 2 variables. ROOT keeps a history of the commands you have entered in a file that is called $HOME/.root_hist and you can recall previous commands by using the arrow keys on your keyboard.

ROOT Interactive Command	What does this command do?

TFile *my = new TFile("htt_175a.root");
my->cd("TOPPLOT");
h21->Draw("L1_px");
h21->Draw("L1_py", ,"same");
	To also display "L1_py" on the current display that shows L1_px

h21->Draw("L1_px:L1_py");	Display L1_px and L1_py as a scatter plot
h21->Draw("L1_px:L1_py", ,"lego");	Draw as a lego plot
h21->Draw("L1_px:L1_py", "L1_pz<50");	Draw with a cut
h21->Draw("L1_px:L1_py", "L1_pz<50","cont");	Draw with cut as a contour plot

Although we haven't covered this in the tutorial, here are some examples of commands used when **creating new ROOT files.** Files can contain any kind of ROOT objects, such as histograms or canvases. When you create a histogram or root tree/ntuple, ROOT will automatically attach it to the ROOT file. Graphical objects, such as a new canvas that you create and want to put it into a saved ROOT file, have to be explicitly attached to the file.

The choices for the second parameter on the TFile constructor are: RECREATE, NEW, CREATE, READ, and UPDATE. The NEW and CREATE have the same effect. They will create a new file and open it for writing, but if the file already exist it is not opened. RECREATE will also create a new file and if the file already exists it will be overwritten. UPDATE will open an existing file for writing. READ will open an existing file as read only.

In the box below are commands to create a new ROOT file, and then create and save a new histogram and a new canvas in the ROOT file that you have created.

ROOT Interactive Command	What does this command do?
gROOT->Reset();	Clear ROOT
TCanvas *mc1 = new TCanvas("mc1","My canvas");	Create a new canvas
TFile *hfile = new TFile("newfile.root","RECREATE");	Create a new **.root** file that we name as "newfile.root"
TH1F *hr = new TH1F("hr"," Random",20,0,10);	Create a new histogram "hr" and fill the histogram with random numbers

gRandom->SetSeed();
{
for (Int_t i=0; i<500; i++) {
Float_t random = gRandom->Rndm(1)*10;
hr->Fill(random);
}
}
	To start a multi line command from the command line, you type an opening curly bracket .
	The prompt changes and you can type the next line of the multiline command. The prompt stays in the multiline mode until you enter a matching closing curly bracket. At that time, the prompt returns to the single line mode.

hr->Draw();	Draw the histogram "hr"
mc1->Modified(); mc1->Update();	Update the canvas "mc1"
hfile->Append(mc1);	Explicitly attach the canvas to the file (If the object is a histogram or a ntuple/tree, ROOT automatically attaches it to the file)
hfile->Write();	Save the file

TDirectory *d = hfile->mkdir("MyTop");	Create a subdirectory of your ROOT file with a pointer named "d"

TCanvas *mc2= new TCanvas("mc2","My canvas");
f1= new TF1("f1","abs(sin(x)/x)",0,10);
f1->Draw();
	Make a canvas and fill with a display

d->Append(mc2);	Add the canvas to the subdirectory
gDirectory->Append(mc2);	Another way to add canvas to subdirectory
hfile->Write();	Save file
hfile->Close();	Close file

Helpful Hints

A helpful hint: ROOT's Class Index

Root is object oriented, and at the heart of ROOT is the usage of classes. When you are using ROOT commands you will be making use of ROOT classes. (All ROOT classes begin with a capital T ,for example: TBrowser, TFile, TCanvas, TPaveLabel.)

The homepage site for ROOT provides a complete index to ROOT classes. So, if any point, you want a full description of a particular class with its methods and members, you can go to the Class Index which is located at:

http://root.cern.ch/root/html/ClassIndex.html

Click on the class you want. When that class window appears you click on Class Description. For example, going to the class description of TFile gives an explanation of the possible options (new, recreate, update, read) that are used in the TFile command.

Another helpful hint: The command line's tab feature

When you are entering commands on the command line, ROOT provides a very helpful tab-tab feature. You type in a variable followed by an arrow, for example:

gStyle-> and then enter a tab

This prints out on your display a listing of all the methods and members of gStyle.

This list is all of the things that you can do in the gStyle command at this point.

Now you can continue by typing in:

gStyle-> SetOpt<tab>

and it will display a list of all the methods and members that start with SetOpt.

Now type:

gStyle-> SetOptS<tab>

and it completes the line to say: gStyle-> SetOptStat

Hit the tab key again and a list of the parameters that are expected for this method will appear. If the method has multiple signatures all of them are displayed.

And one more helpful hint for macros: Saving the ROOT canvas display as a macro and using the root.history file

In the above examples of ROOT commands there is an example for putting a pave label into a histogram display. The easiest way to do this is to use the graphic interface, just as we did in Part 1. You can set up a Pave Label using the **Editor** that is located under the canvas menu item **Edit** . Once you have the display set up in a way you like, you can use the option **Save as canvas.C** , located under the canvas menu item **File.** This creates a skeletal macro with the default name of the canvas you have on display followed by ".C" (e.g. c1.C). The skeletal macro would have the ROOT command coding for the pave label with its position on the canvas. The macro will require some editing, but can be a useful basis for a macro that you would create for your own use. Additionally, a history of the commands that you entered during ROOT sessions is stored in text file called **root_history.txt**. Commands can be copied out of this text file and placed into the text file that you create as the script (the series of running commands) of your macro.

PART 4: FURTHER DOCUMENTATION ABOUT ROOT

We hope this tutorial has given you a small introduction to ROOT and that you will now be interested in going out into the wide world of ROOT to learn and make use of its more advanced functionality when using it as a physics analysis tool. There is a wealth of material about ROOT available via the web, particularly through the homepage of ROOT where the creators of ROOT, Rene Brun ,Fons Rademakers and their team, have provided an enormous amount of documentation .

The ROOT Homepage is the **official ROOT web site**. The location is: http://root.cern.ch. Some very useful locations within this site to the beginner user are given below. All of them can be accessed from the listing that appears on the Homepage.

Search the ROOT Web Site. **For on-line help** or a search on a particular topic it's very useful to use this facility. The location is: http://root.cern.ch/root/Search.phtml

The ROOT Tutorials are a description of tools that you will be using in ROOT for a PAW style analysis. It gives examples of creating histograms/ntuples, fits, functions,etc. with **sample macros.** . The location is: http://root.cern.ch/root/Tutorials.html

The ROOT How To's are an introduction to the infrastructure of ROOT and give examples of **how to write code within ROOT classes.** . The location is: http://root.cern.ch/root/Howto.html

Classes and Members Reference Guide is an index to ROOT classes with **full class description, including options** to commands using the class. The location is http://root.cern.ch/root/html/ClassIndex.html

The Publication List is a list of ROOT related publications. At the bottom of the list is non official ROOT documentation. It is located at: http://root.cern.ch/root/Publications.html

There is a ROOT talk mailing list. Subscribe via:

http://root.cern.ch/cgi-bin/registration.pl

To submit a bug report : http://pcroot.cern.ch/root-bugs.

You can search and browse the Bug Database before submitting your own bug report.

Setting up Root on Fermi Systems

1. Log on to cdfsga, fnalu, fnpat1, or d02ka

2. On cdfsga type:

```
:>setup root v2_22_09 -q KCC_3_3
```

You may need to set up your environment. At the system prompt type:

```
:>source ~cdfsoft/.cshrc
```

On fnalu type:

```
:>setup root v2_22_09
```

On d02ka type:

```
:>setup root v2_22_09 -q KCC_3_3:exception
```

On fnpat1 type:

```
:>setup root v2_22_09 -q KCC_3_3
```

3. Startup root by typing at the system prompt:

```
:> root
```

4. Quit root by typing .q at the root prompt

```
root:> .q
```

A QUICK REFERENCE TO ROOT COMMANDS used in GETTING STARTED

Axis: give the axis a title	myh1->GetXaxis()->SetTitle("X-Axis");
Axis: center the title	myh1->GetXaxis()->CenterTitle(1);
Browser: create a ROOT Browser	TBrowser *b = new TBrowser();
Canvas: manually create a canvas	myc1=new TCanvas("myc1","My canvas");
Canvas: automatically generate 4 pads	myc1->Divide(2,2);
Canvas: set pad1 "myc1_1" as active pad	myc1_1->cd();
Canvas: print the display of a canvas	c1->Print();
Canvas: refresh canvas "mc1" on screen	mc1->Update();
Cuts: examples	h21->Draw("L1_py","(L1_px<0) "); h21->Draw("L1_px","(L1_py<.5) && (L1_pz>10)");
Directory: list contents of current directory	gDirectory->ls();
Directory: change directory	my->cd("TOPPLOT");
Directory: create a subdirectory	TDirectory *d = hfile->mkdir("MyTop");
Directory: add canvas "mc2" to subdir Directory: add object to current directory	d->Append(mc2); gDirectory->Append(mc2);
End a ROOT session	.q
File: Open a file	TFile *my = new TFile("htt_175a.root");
Files: create new .root file	TFile *hfile = new TFile("newfile.root","RECREATE");
Files: save file	hfile->Write();
Files: close file	hfile->Close();
File: switching between files	hfile->cd();
File: list contents of a file	my->ls();
Files: attach object to a file	hfile->Append(mc1);
Fits: fit histogram "his1" with a gaussian fit	his1->Fit("gaus");
Fits: fit histogram with a polynomial fit	his1->Fit("pol9");

Functions: create user designed function	f1= new TF1("f1","abs(sin(x)/x)",0,10);
Functions: exponential function to fit over a subrange	TF1 *e1 = new TF1("e1","expo",0,200); myh1->Fit("e1","R");
Function : set initial values of a parameter	f2->SetParameters(1000000,30);
Global variables: current environment	gEnv->Print();
Global var: list of objects in current session	gObjectTable->Print();
Global variable: clearing ROOT	gROOT->Reset();
Histogram: draw histogram "his1"	his1->Draw();
Histogram: draw a copy as lego view	his1->DrawCopy("lego1");
Histogram : Draw with error bars	h21->Draw("L1_py","","e1");
Histogram: set a fill color	t1->SetFillColor(6);
Histogram: set marker color	h21->SetMarkerColor(2);
Histogram: set marker style	h21->SetMarkerStyle(8);
Histogram: set to log. scale	myc1_4->SetLogy(1);
Histogram: save display as a named hist.	h21->Draw("L1_px>>his1");

Histogram: create & fill with random nos.	TH1F *hr = new TH1F("hr"," Random",20,0,10);
	gRandom->SetSeed();
	{
	for (Int_t i=0; i<500; i++) {
	Float_t random = gRandom->Rndm(1)*10;
	hr->Fill(random);
	}
	}

Pave label: Create a pave label	t1 = new TPaveLabel(-235,1217,-44,1387, "A label","br");
Range: set range of a fit	e1->SetRange(0,200);
Range: fit with range option	myh1->Fit("e1","R");
Range: set 2 subranges of fits on	TF1 *g1 = new TF1("g1","gaus",-200.,200);

one display	TF1 *g2 = new TF1("g2","gaus",-200., 0);
	myh1->Fit("g1","R");
	myh1->Fit("g2","R+");

Scatter plot: display "L1_px" and "L1_py"	h21->Draw("L1_px:L1_py");
Statistics: set to display under and overflow	gStyle->SetOptStat(111111);
Tree: create a TTree Viewer	tv = new TTreeViewer("h21");
Tree: display as a 1-D histogram	h21->Draw("L1_pz");
Tree: display & save as named histogram	h21->Draw("L1_pz>>myh1");
Tree: find names of variables in file	h21->Print();
Tree: " py" on same display as " px"	h21->Draw("py", ,"same");
Tree: 2 -D histogram as a scatter plot	h21->Draw("L1_px:L1_py");
Tree: 2-D scatter plot histogram with a cut	h21->Draw("L1_px:L1_py", "L1_pz<50");
Tree: 2-D contour histogram with cut	h21->Draw("L1_px:L1_py", "L1_pz<50","cont");
Tree: 2-D as a lego plot	h21->Draw("L1_px:L1_py", ,"lego");