ROOT Basics

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This lecture is based on Fermilab ROOT tutorial and ROOT lecture in CERN summer school

Introduction

WHAT IS ROOT ?

- ROOT is an object oriented framework
- It has a C/C++ interpreter (CINT) and C/C++ compiler (ACLIC)
- ROOT is used extensively in High Energy Physics for “data analysis”
    - Reading and writing data files
    - Calculations to produce plots, numbers and fits.

WHY ROOT ?

- It can handle large files (in GB) containing N-tuples and Histograms
- Multiplatform software
- Its based on widely known programming language C++
- Its free

Outline of this lecture

- Overview of ROOT framework
- GUI and command line basics
- CINT: Interpreter for C and C++ code
- Graphs, Histograms and Root Trees
- Functions and fitting

Learning ROOT

- http://root.cern.ch/root/Tutorials.html
- http://root.cern.ch/root/HowTo.html
- http://www-root.fnal.gov/root/
- http://www.slac.stanford.edu/BFROOT/www/doc/workbook/root{1,2,3}/root{1,2,3}.html

ROOT Mailing Lists

- roottalk@root.cern.ch
- http://root.cern.ch/root/roottalk/AboutRootTalk.html

Root Interactive Session

- Set ROOTSYS to the directory where ROOT is installed
- Add ROOT libraries to the LD_LIBRARY_PATH
- Include the ROOT executable binary files to the binary path

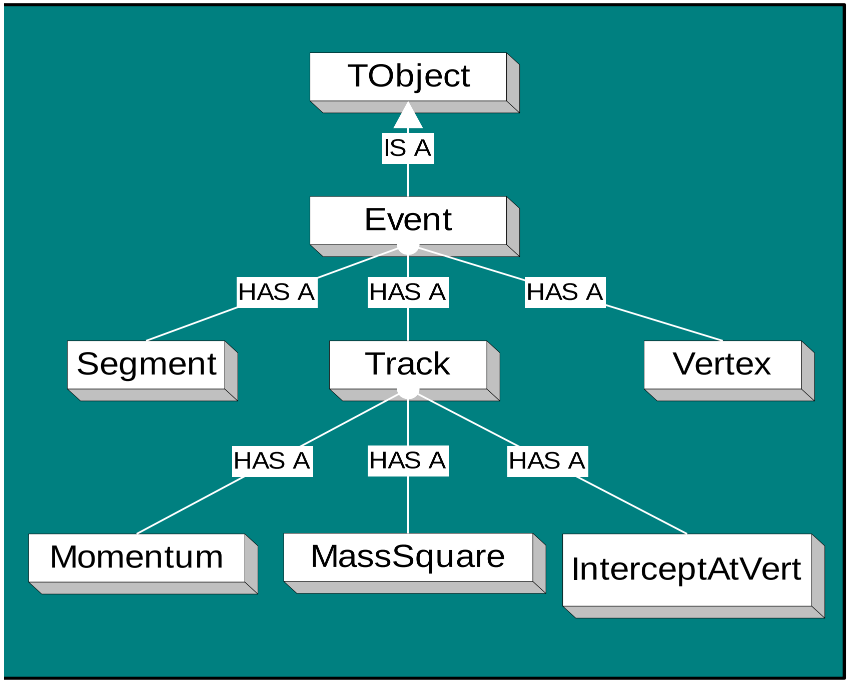
BASH	export ROOTSYS=/cern/root export LD_LIBRARY_PATH=$ROOTSYS/lib:$LD_LIBRARY_PATH export PATH=$ROOTSYS/bin:$PATH
TCSH	setenv ROOTSYS /cern/root setenv LD_LIBRARY_PATH $ROOTSYS/lib:$LD_LIBRARY_PATH setenv PATH $ROOTSYS/bin:$PATH

- You may add the above lines to your ~/.cshrc or ~/.bashrc
- You may define your root settings in ~/.rootlogon.C
- History of all commands are stored in ~/.root_hist

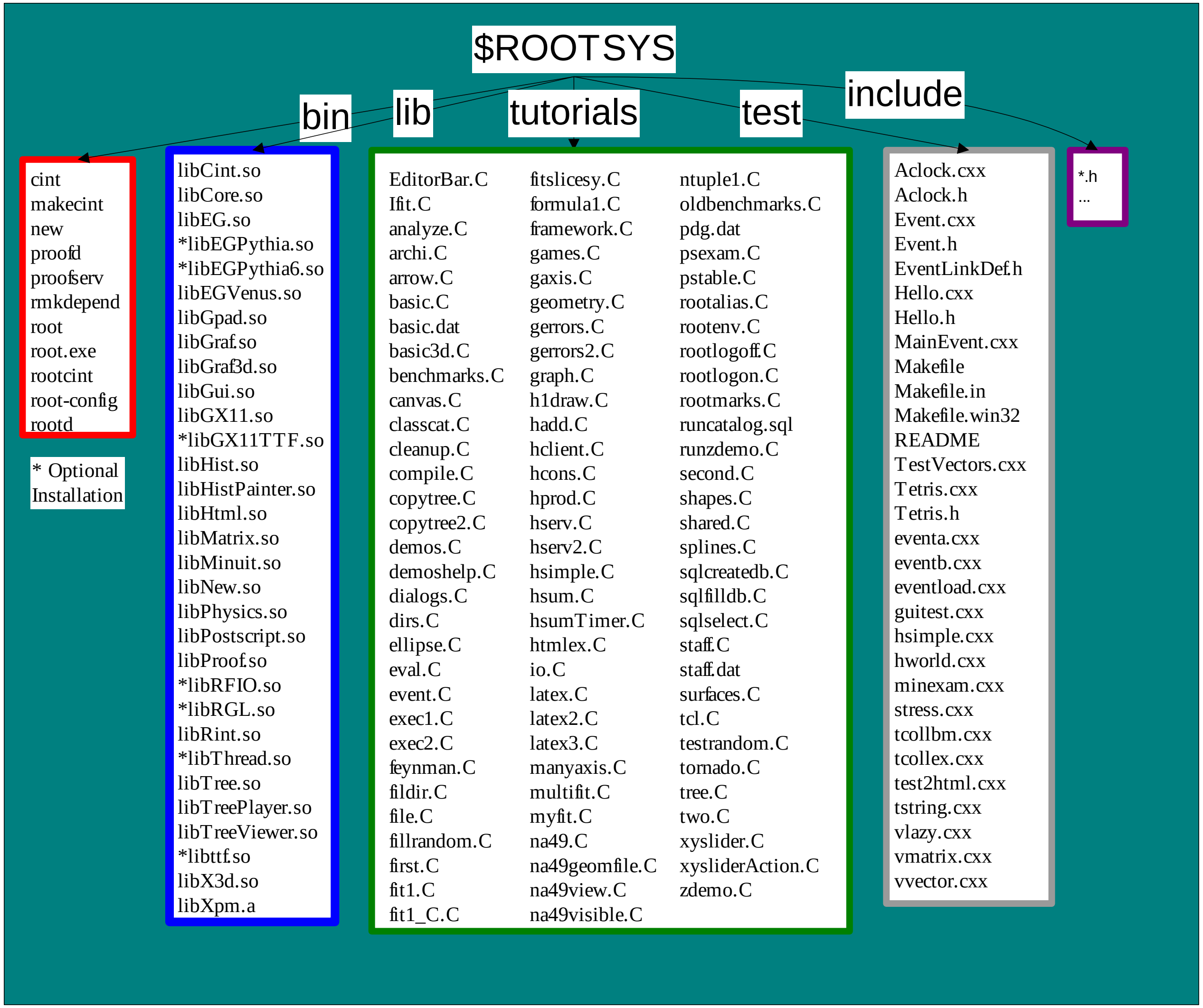
Object Oriented Concepts

- Class: the description of a “thing” in the system
- Object: instance of a class
- Methods: functions for a class

- Members: a “has a” relationship to the class.
- Inheritance: an “is a” relationship to the class.



The Framework Organization



$ROOTSYS

bin

cint
makecint
new
proofd
proofserv
rmkdepend
root
root.exe
rootcint
root-config
rootd

* Optional
Installation

lib

libCint.so
libCore.so
libEG.so
*libEGPythia.so
*libEGPythia6.so
libEGVenus.so
libGpad.so
libGraf.so
libGraf3d.so
libGui.so
libGX11.so
*libGX11TTF.so
libHist.so
libHistPainter.so
libHtml.so
libMatrix.so
libMinuit.so
libNew.so
libPhysics.so
libPostscript.so
libProof.so
*libRFIO.so
*libRGL.so
libRint.so
*libThread.so
libTree.so
libTreePlayer.so
libTreeViewer.so
*libttf.so
libX3d.so
libXpm.a

tutorials

EditorBar.C
Ifit.C
analyze.C
archi.C
arrow.C
basic.C
basic.dat
basic3d.C
benchmarks.C
canvas.C
classcat.C
cleanup.C
compile.C
copytree.C
copytree2.C
demos.C
demoshelp.C
dialogs.C
dirs.C
ellipse.C
eval.C
event.C
exec1.C
exec2.C
feynman.C
fildir.C
file.C
fillrandom.C
first.C
fit1.C
fit1_C.C
fitslicesy.C
formula1.C
framework.C
games.C
gaxis.C
geometry.C
gerrors.C
gerrors2.C
graph.C
h1draw.C
hadd.C
hclient.C
hcons.C
hprod.C
hserv.C
hserv2.C
hsimple.C
hsum.C
hsumTimer.C
htmlex.C
io.C
latex.C
latex2.C
latex3.C
manyaxis.C
multifit.C
myfit.C
na49.C
na49geomfile.C
na49view.C
na49visible.C
ntuple1.C
oldbenchmarks.C
pdg.dat
psexam.C
pstable.C
rootalias.C
rootenv.C
rootlogoff.C
rootlogon.C
rootmarks.C
runcatalog.sql
runzdemo.C
second.C
shapes.C
shared.C
splines.C
sqlcreatedb.C
sqlfilldb.C
sqlselect.C
staff.C
staff.dat
surfaces.C
tcl.C
testrandom.C
tornado.C
tree.C
two.C
xyslider.C
xysliderAction.C
zdemo.C

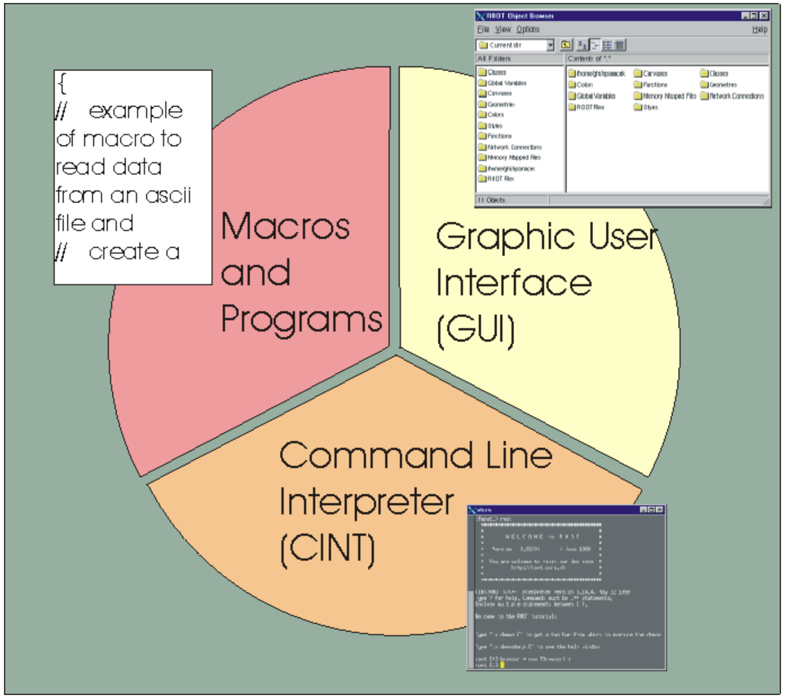
test

Aclock.cxx
Aclock.h
Event.cxx
Event.h
EventLinkDef.h
Hello.cxx
Hello.h
MainEvent.cxx
Makefile
Makefile.in
Makefile.win32
README
TestVectors.cxx
Tetris.cxx
Tetris.h
eventa.cxx
eventb.cxx
eventload.cxx
guitest.cxx
hsimple.cxx
hworld.cxx
minexam.cxx
stress.cxx
tcollbm.cxx
tcollex.cxx
test2html.cxx
tstring.cxx
vlazy.cxx
vmatrix.cxx
vvector.cxx

include

*.h
...

User Interfaces



```
{
//   example
of macro to
read data
from an ascii
file and
//   create a
```

```
corvair:~> setenv ROOTSYS /cern/root
corvair:~> setenv LD_LIBRARY_PATH $ROOTSYS/lib:$LD_LIBRARY_PATH
corvair:~> setenv PATH $ROOTSYS/bin:$PATH
corvair:~> root
  *******************************************
  *                                         *
  *        W E L C O M E  to  R O O T       *
  *                                         *
  *   Version   5.16/00      27 June 2007   *
  *                                         *
  *  You are welcome to visit our Web site  *
  *          http://root.cern.ch            *
  *                                         *
  *******************************************

Compiled on 29 June 2007 for linux with thread support.

CINT/ROOT C/C++ Interpreter version 5.16.21, June 22, 2007
Type ? for help. Commands must be C++ statements.
Enclose multiple statements between { }.
root [0] 
```

.q	**Quit**
.L macro.C	Load a macro file
.x macro.C	Load and execute a macro file
.x macro.C++	Compile and execute

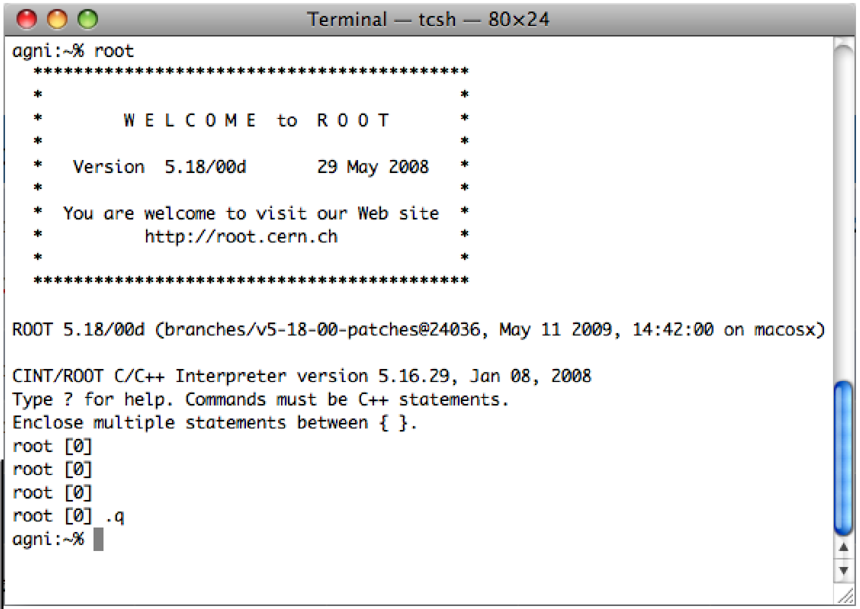
GUI Basics

Start root

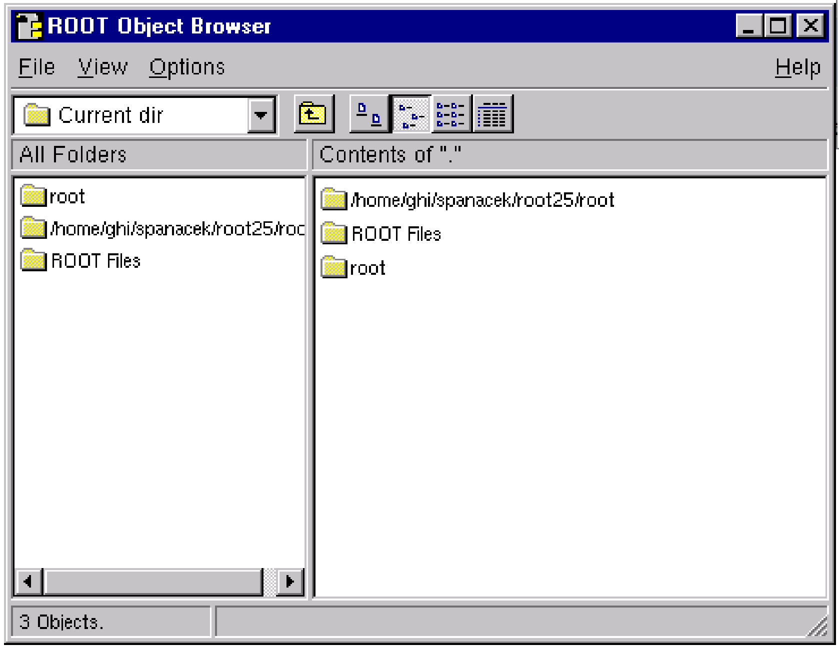
> root

Quit root (just in case)

root[0]>.q



```
agni:~% root
  *******************************************
  *                                         *
  *        W E L C O M E  to  R O O T       *
  *                                         *
  *   Version  5.18/00d       29 May 2008   *
  *                                         *
  *  You are welcome to visit our Web site  *
  *          http://root.cern.ch            *
  *                                         *
  *******************************************

ROOT 5.18/00d (branches/v5-18-00-patches@24036, May 11 2009, 14:42:00 on macosx)

CINT/ROOT C/C++ Interpreter version 5.16.29, Jan 08, 2008
Type ? for help. Commands must be C++ statements.
Enclose multiple statements between { }.
root [0]
root [0]
root [0]
root [0] .q
agni:~% 
```



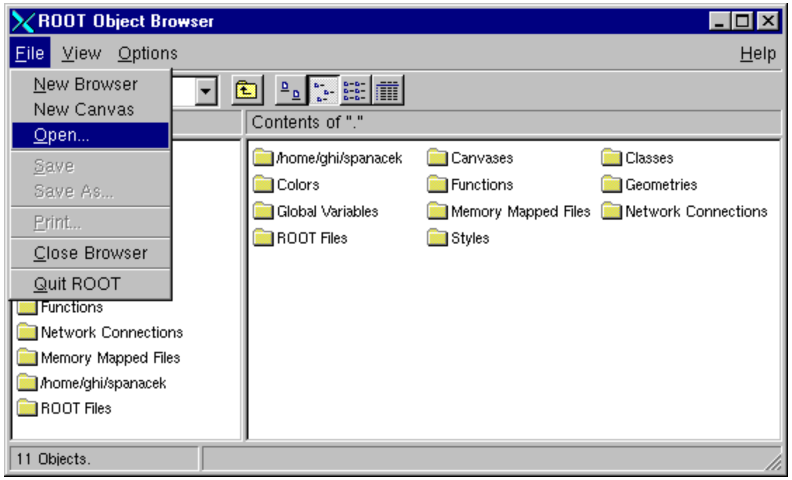
Display the browser

TBrowser b;

Displaying a Histogram

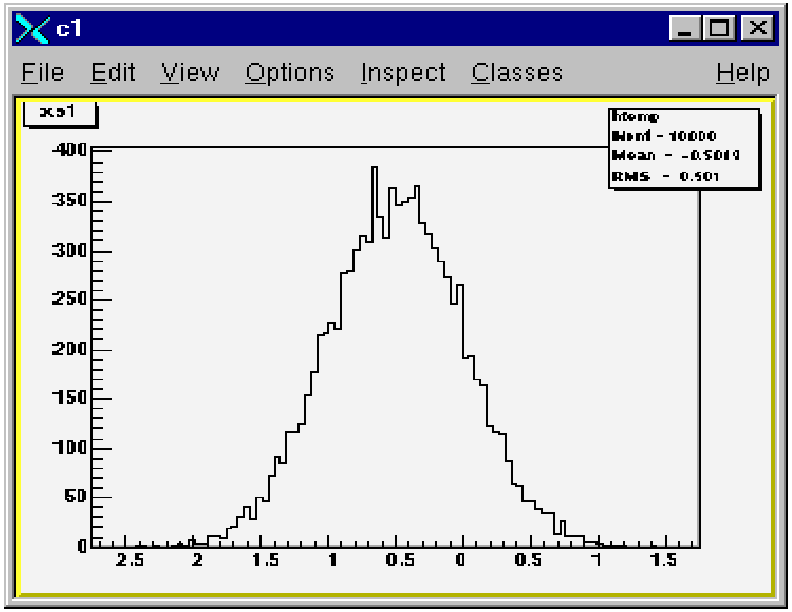
Open the root file

Browse the file



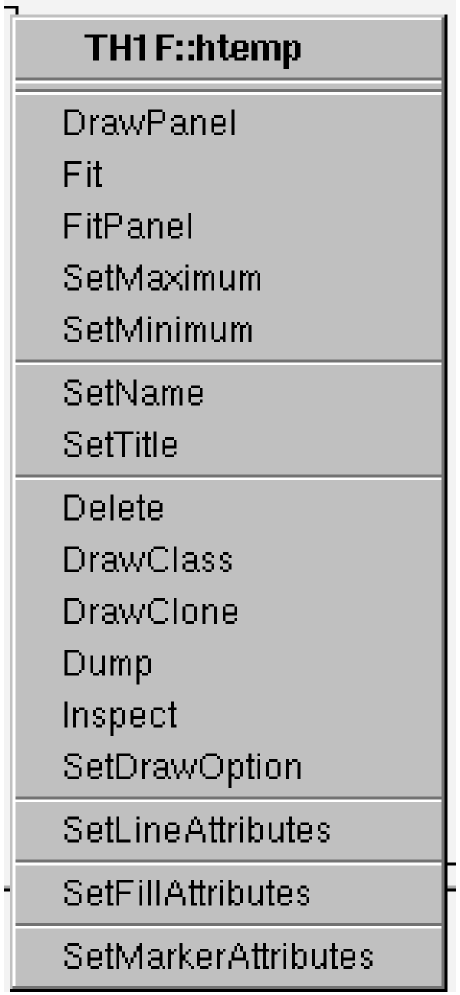
Display a histogram

The Canvas

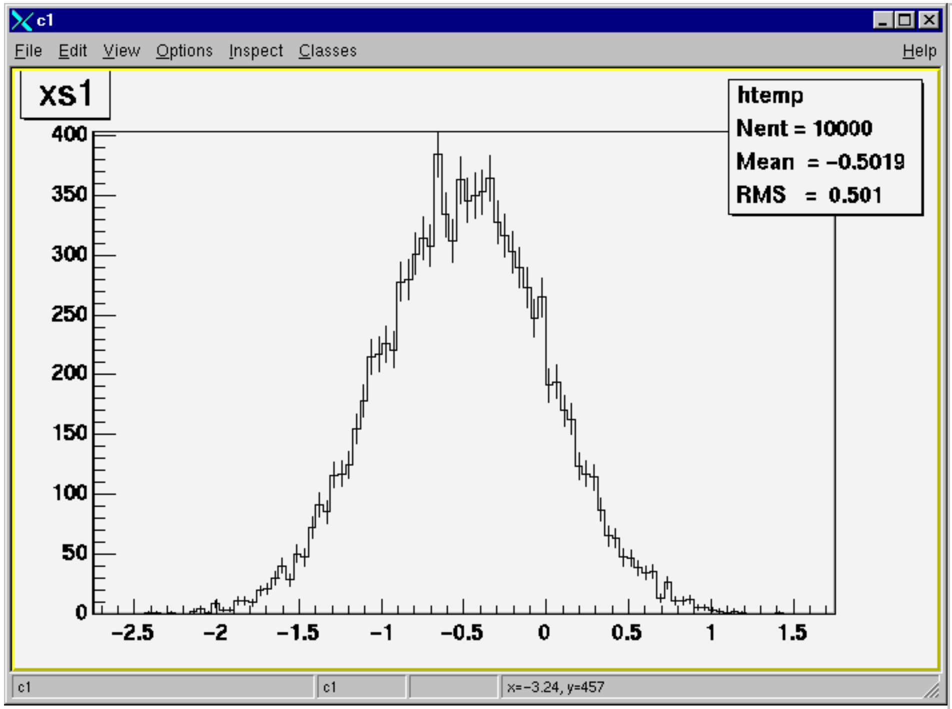


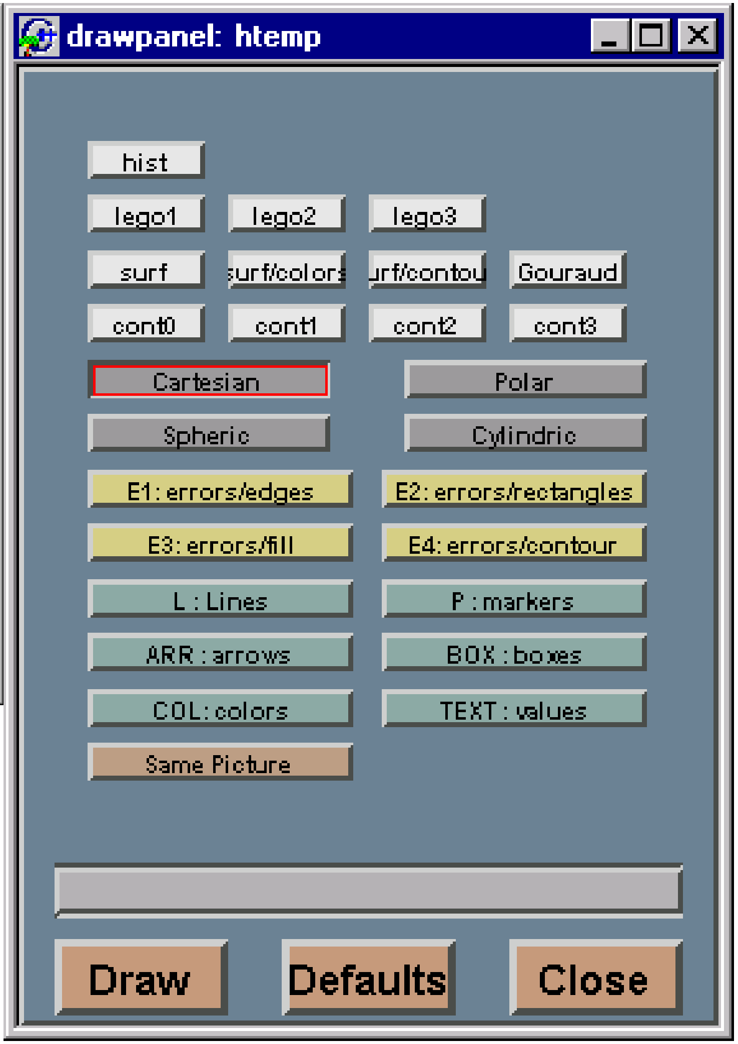
Basic Navigation by Clicking

- Left Click
  - select the object
  - drag the object
  - resize the object
- Right Click
  - context menu
  - class::name
  - methods
- Middle Click
  - activate canvas
  - freezes event status bar

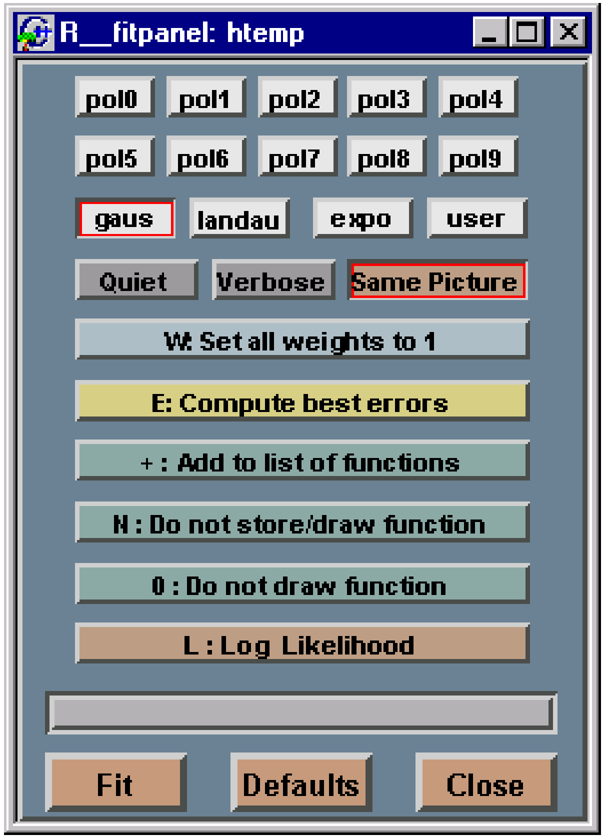


The Draw Panel

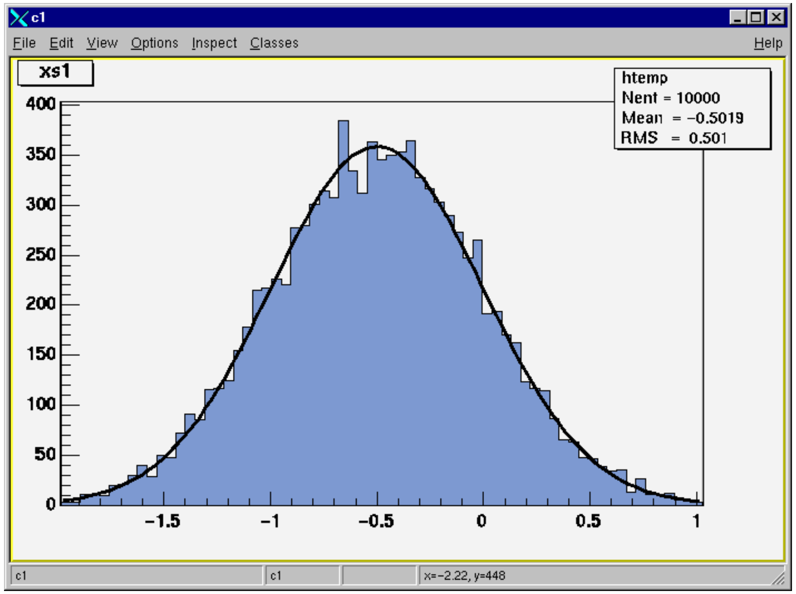




Fitting, Coloring, and Zooming

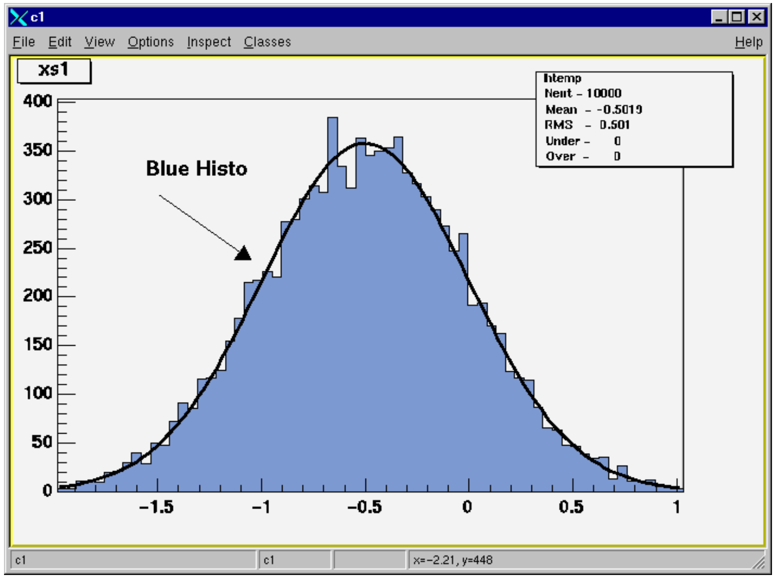


- Adding a gaussian fit
- Coloring the histogram
- Zooming/unzooming



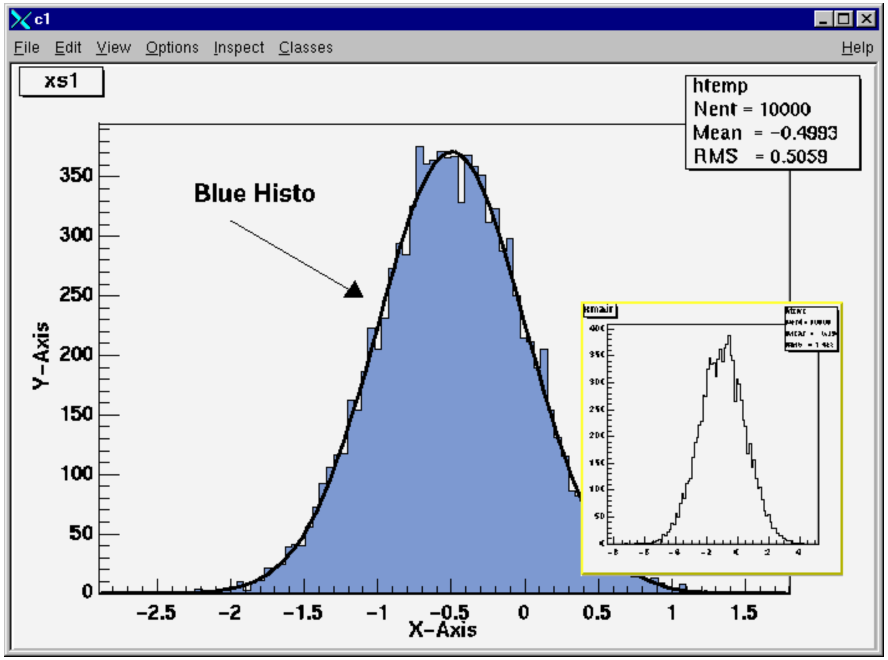
Adding Objects to the Canvas

- The Editor
- Adding an Arrow
- Adding Text



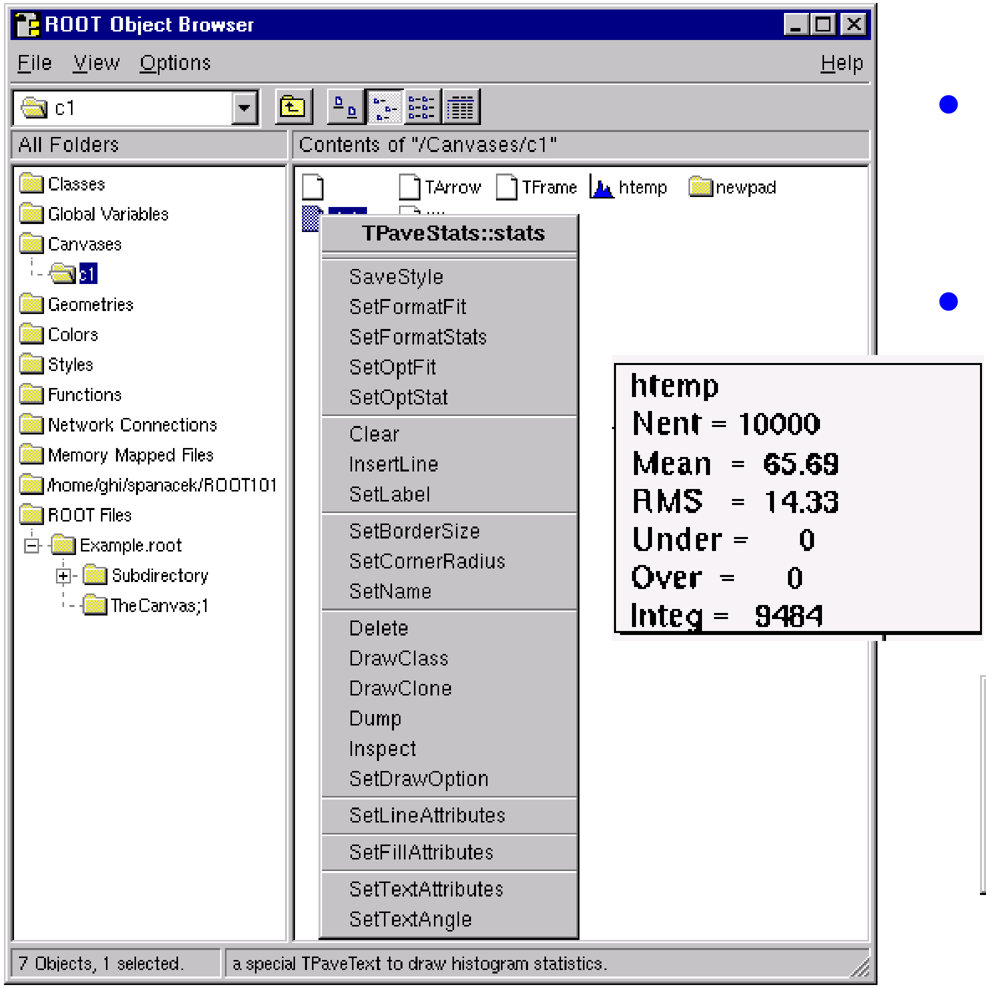
```
htemp
Nent - 10000
Mean  - -0.5019
RMS  -  0.501
Under -     0
Over  -     0
```

Adding another Pad



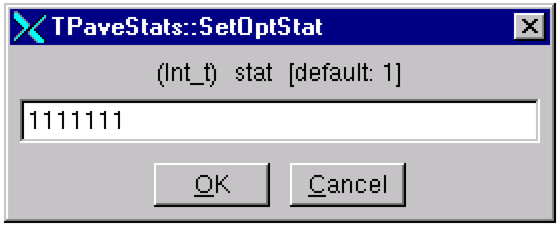
- Add a Pad
- Select the new Pad
- Draw a histogram
- Add a title for the axis

Modifying the Statistics



```
htemp
Nent = 10000
Mean  =  65.69
RMS   =  14.33
Under =     0
Over  =     0
Integ =  9484
```

- The Canvas in the Browser
- Setting the (7) statistics options
  - default = 0001111



(Int_t) stat [default: 1]

1111111

Reading & Storing Data in Root

- Data can be read from files/database/network
- Data is generally stored as a TTree/TNtuple (similar to a table with rows and columns)
- Each row represents an event
- Each column represents a quantity
- Trees can be created from ASCII files.

Read data from ASCII file to Root File

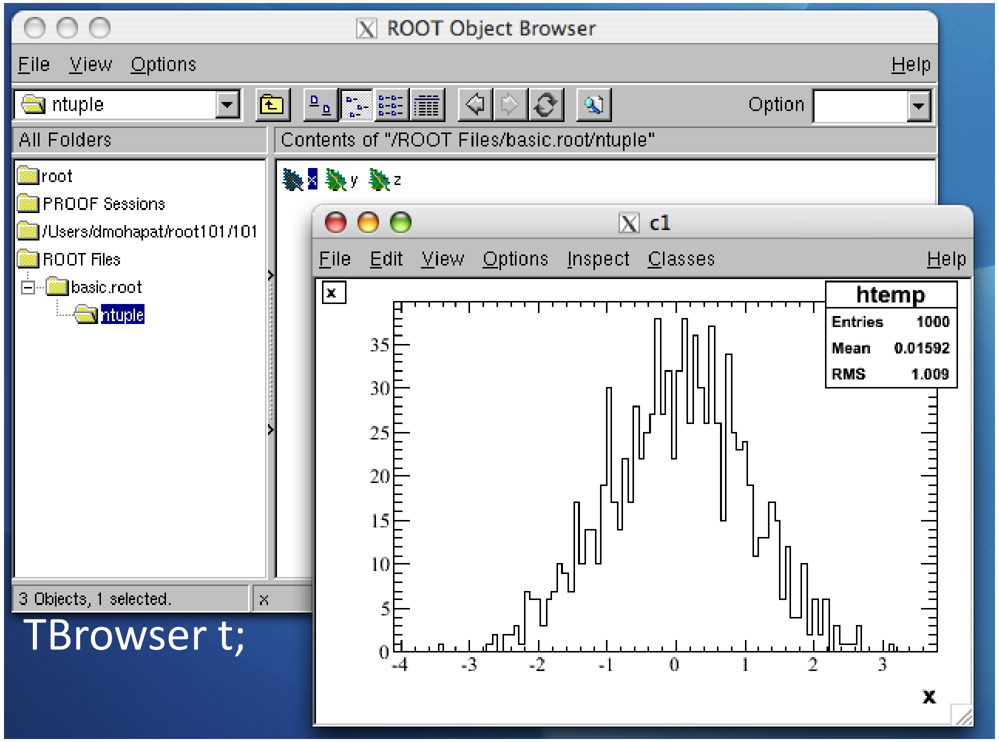
basic.dat

```
-1.102279   -1.799389   4.452822
1.867178    -0.596622   3.842313
-0.524181   1.868521    3.766139
-0.380611   0.969128    1.084074
0.552454    -0.212309   0.350281
-0.184954   1.187305    1.443902
0.205643    -0.770148   0.635417
1.079222    -0.327389   1.271904
-0.274919   -1.721429   3.038899
2.047779    -0.062677   4.197329
-0.458677   -1.443219   2.293266
0.304731    -0.884636   0.875442
-0.712336   -0.222392   0.556881
-0.271866   1.181767    1.470484
0.886202    -0.654106   1.213209
-2.035552   0.527648    4.421883
-1.459047   -0.463998   2.344113
1.230661    -0.005650   1.514559
0.088787    1.885329    3.562347
-0.314154   -0.329161   0.207040
-0.198253   0.646070    0.456712
-1.636217   1.049551    3.778762
1.221109    0.814383    2.154327
1.413135    1.549837    4.398942
-0.174494   -1.330937   1.801841
-1.464173   -0.912864   2.977124
…           …           …
```

tree.C

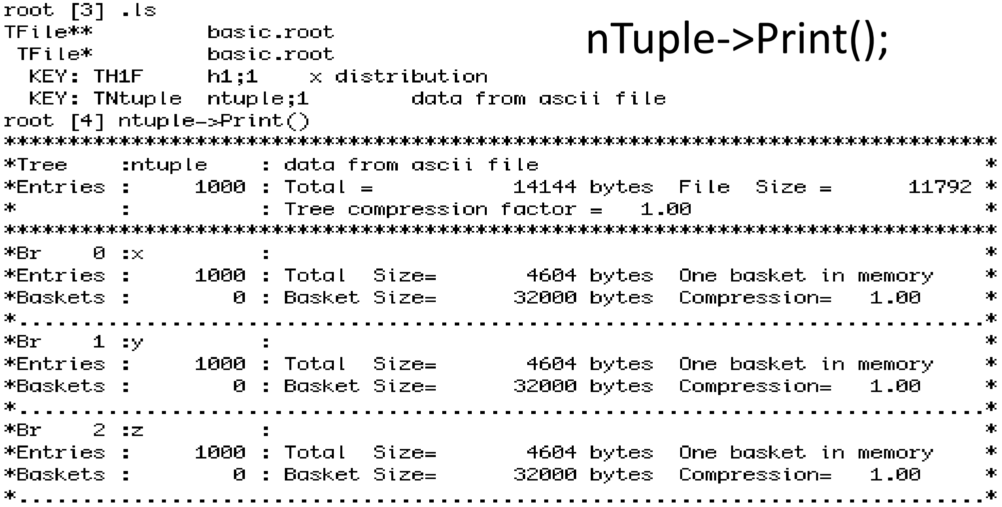
```
#include "Riostream.h"
void tree() {
  ifstream in;
  in.open(Form("basic.dat"));

  Float_t x,y,z;
  Int_t nlines = 0;
  TFile *f = new TFile("basic.root","RECREATE");
  TH1F *h1 = new TH1F("h1","x distribution",100,-4,4);
  TNtuple *ntuple = new TNtuple("ntuple","data from ascii file","x:y:z");

  while (1) {
    in >> x >> y >> z;
    if (!in.good()) break;
    if (nlines < 5) printf("x=%8f, y=%8f, z=%8f\n",x,y,z);
      h1->Fill(x);
      ntuple->Fill(x,y,z);
    nlines++;
  }
  printf(" found %d points\n",nlines);

  in.close();


   f->Write();
}
```

Read the Root file and the Tree



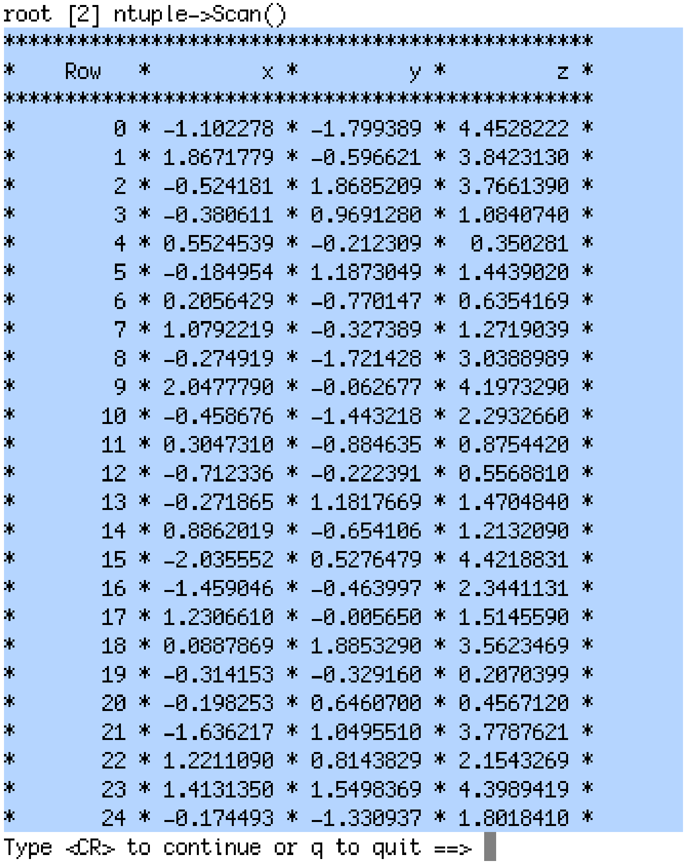
TBrowser t;

nTuple->Print();



```
root [3] .ls
TFile**         basic.root
 TFile*         basic.root
  KEY: TH1F     h1;1    x distribution
  KEY: TNtuple  ntuple;1        data from ascii file
root [4] ntuple->Print()
******************************************************************************
*Tree    :ntuple    : data from ascii file                                   *
*Entries :     1000 : Total =           14144 bytes  File  Size =      11792 *
*        :          : Tree compression factor =   1.00                       *
******************************************************************************
*Br    0 :x         :                                                        *
*Entries :     1000 : Total  Size=       4604 bytes  One basket in memory    *
*Baskets :        0 : Basket Size=      32000 bytes  Compression=   1.00     *
*............................................................................*
*Br    1 :y         :                                                        *
*Entries :     1000 : Total  Size=       4604 bytes  One basket in memory    *
*Baskets :        0 : Basket Size=      32000 bytes  Compression=   1.00     *
*............................................................................*
*Br    2 :z         :                                                        *
*Entries :     1000 : Total  Size=       4604 bytes  One basket in memory    *
*Baskets :        0 : Basket Size=      32000 bytes  Compression=   1.00     *
*............................................................................*
```

ntuple->Scain();



```
root [2] ntuple->Scan()
************************************************
*    Row   *         x *         y *         z *
************************************************
*        0 * -1.102278 * -1.799389 * 4.4528222 *
*        1 * 1.8671779 * -0.596621 * 3.8423130 *
*        2 * -0.524181 * 1.8685209 * 3.7661390 *
*        3 * -0.380611 * 0.9691280 * 1.0840740 *
*        4 * 0.5524539 * -0.212309 *  0.350281 *
*        5 * -0.184954 * 1.1873049 * 1.4439020 *
*        6 * 0.2056429 * -0.770147 * 0.6354169 *
*        7 * 1.0792219 * -0.327389 * 1.2719039 *
*        8 * -0.274919 * -1.721428 * 3.0388989 *
*        9 * 2.0477790 * -0.062677 * 4.1973290 *
*       10 * -0.458676 * -1.443218 * 2.2932660 *
*       11 * 0.3047310 * -0.884635 * 0.8754420 *
*       12 * -0.712336 * -0.222391 * 0.5568810 *
*       13 * -0.271865 * 1.1817669 * 1.4704840 *
*       14 * 0.8862019 * -0.654106 * 1.2132090 *
*       15 * -2.035552 * 0.5276479 * 4.4218831 *
*       16 * -1.459046 * -0.463997 * 2.3441131 *
*       17 * 1.2306610 * -0.005650 * 1.5145590 *
*       18 * 0.0887869 * 1.8853290 * 3.5623469 *
*       19 * -0.314153 * -0.329160 * 0.2070399 *
*       20 * -0.198253 * 0.6460700 * 0.4567120 *
*       21 * -1.636217 * 1.0495510 * 3.7787621 *
*       22 * 1.2211090 * 0.8143829 * 2.1543269 *
*       23 * 1.4131350 * 1.5498369 * 4.3989419 *
*       24 * -0.174493 * -1.330937 * 1.8018410 *
Type <CR> to continue or q to quit ==>
```

What do we learn from this Macro

How to	Commands

Create a Root file ?	TFile *f = new TFile("basic.root","RECREATE");
	//option: NEW, CREATE, RECREATE, UPDATE, or READ
	//Book and fill histograms and trees
	//------
	f->Write(); //write the file
	f->Close(); //close the file

Book and fill a histogram ?	TH1F *h1 = new TH1F("h1","x distribution",100,-4,4); /*do some calculation and get the parameter that you want to fill*/ h1->Fill(x);
Book and fill a tree ?	TNtuple *ntuple = new TNtuple("ntuple","data from ascii file","x:y:z"); /*do some calculation and get the parameter that you want to fill*/ ntuple->Fill(x,y,z);
CINT Data types	Int_t and Float_t (see http://root.cern.ch/root/html/ListOfTypes.html)

Root Data Types

C++ type	**Size (bytes)**	**ROOT types**	**Size (bytes)**	**FORTRAN analog**
(unsigned)char	1	(U)Char_t	1	CHARACTER*1
(unsigned)short (int)	2	(U)Short_t	2	INTEGER*2
(unsigned)int	2 or 4	(U)Int_t	4	INTEGER*4
(unsigned)long (int)	4 or 8	(U)Long_t	8	INTEGER*8
float	4	Float_t	4	REAL*4
double	8 (=4)	Double_t	8	REAL*8
long double	16 (= double)			REAL*16

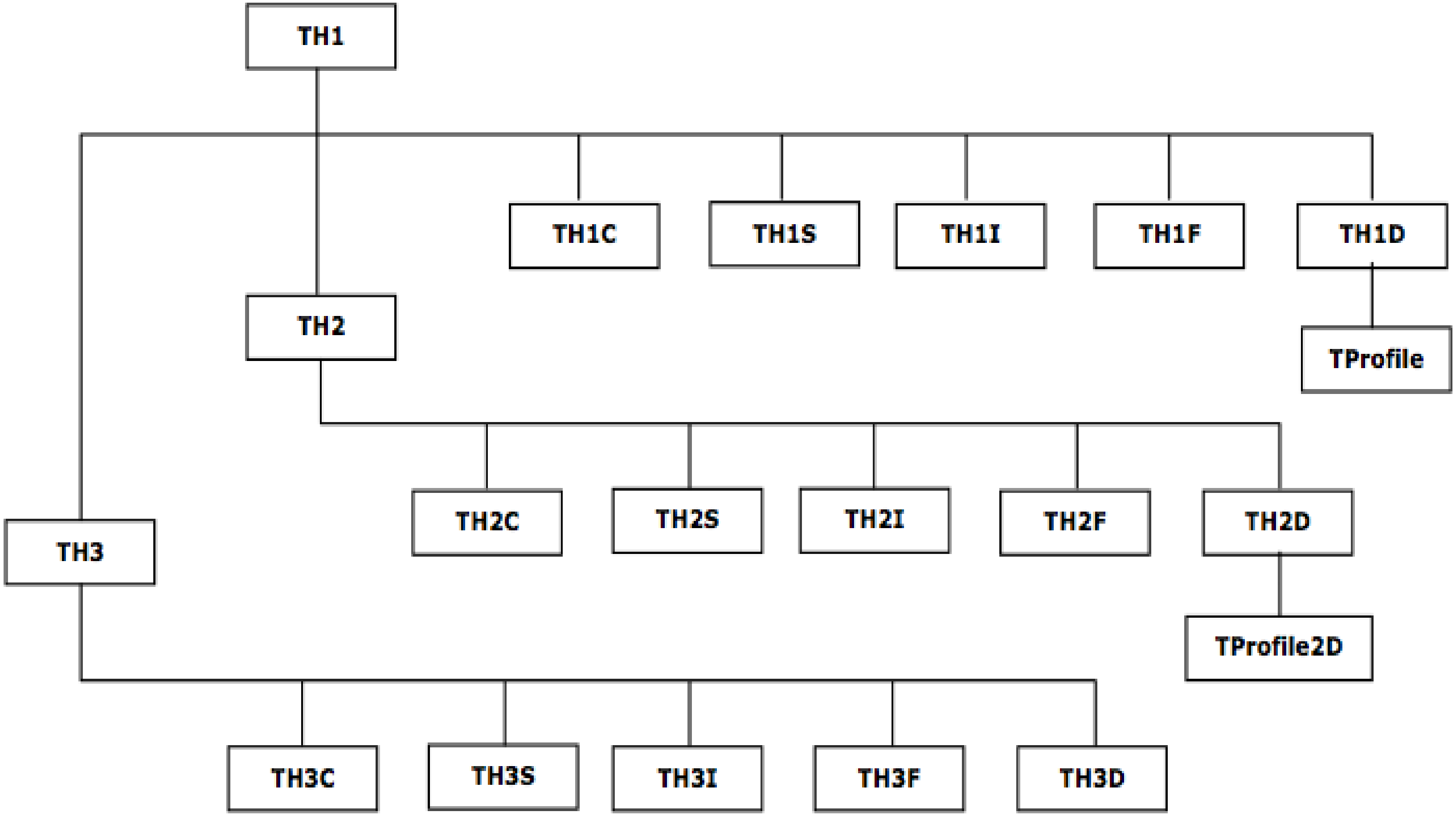
How to Compile a Macro ?

Running the macro **root [0] .x tree.C or,** **root [0] .L tree.C** **root [1] tree()**	**Compiling the macro** **root [0] .L tree1.C++** **root [1] main()**

```
#include "Riostream.h"
void tree(){
  ifstream in;
  in.open(Form("basic.dat"));

  Float_t x,y,z;
  Int_t nlines = 0;
  TFile *f = new TFile("basic.root","RECREATE");
  TH1F *h1 = new TH1F("h1","x distribution",100,-4,4);
  TNtuple *ntuple = new TNtuple("ntuple","data from ascii file","x:y:z");

  while (1) {
    in >> x >> y >> z;
    if (!in.good()) break;
    if (nlines < 5) printf("x=%8f, y=%8f, z=%8f\n",x,y,z);
    h1->Fill(x);
    ntuple->Fill(x,y,z);
    nlines++;
  }
  printf(" found %d points\n",nlines);

  in.close();
  f->Write();
  f->Close();

}
```

```
#include "Riostream.h"
#include "TFile.h"
#include "TH1.h"
#include "TNtuple.h"

int main() {
  ifstream in;
  in.open(Form("basic.dat"));

  Float_t x,y,z;
  Int_t nlines = 0;
  TFile *f = new TFile("basic.root","RECREATE");
  TH1F *h1 = new TH1F("h1","x distribution",100,-4,4);
  TNtuple *ntuple = new TNtuple("ntuple","data from ascii file","x:y:z");

  while (1) {
    in >> x >> y >> z;
    if (!in.good()) break;
    if (nlines < 5) printf("x=%8f, y=%8f, z=%8f\n",x,y,z);
    h1->Fill(x);
    ntuple->Fill(x,y,z);
    nlines++;
  }
  printf(" found %d points\n",nlines);

  in.close();
  f->Write();
  f->Close();
  return 0;
}
```

Histograms in Root: 1D, 2D and 3D



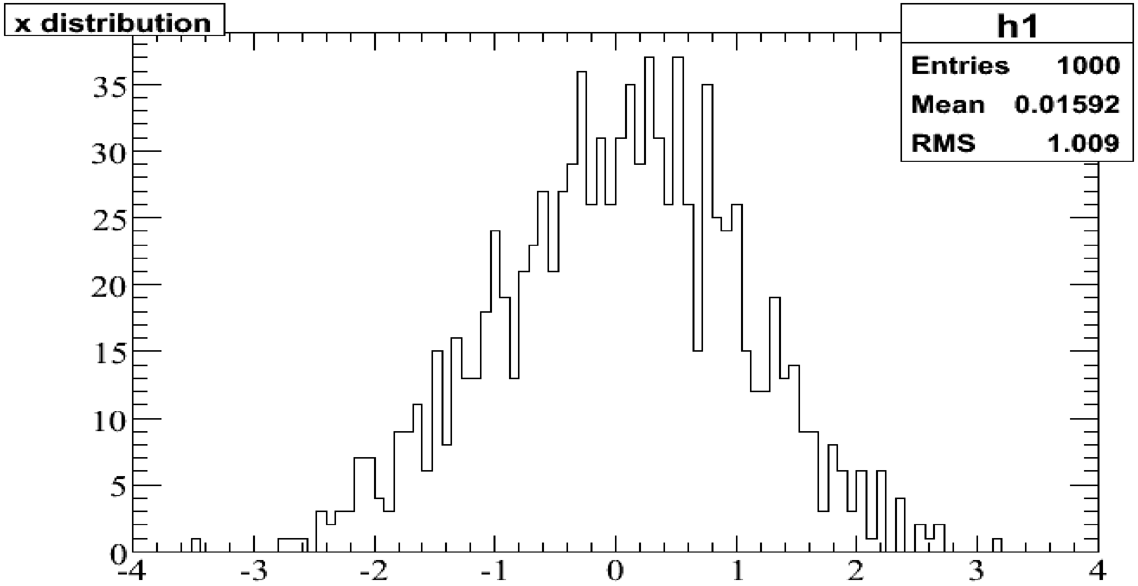
✓Floats: Max bin content – 7 digits
✓Double: Max bin content – 14 digits

1D Histograms: TH1

- TH1F *name = new TH1F(”name",”Title”, Bins, lowest bin, highest bin);

Example:

- TH1F *h1 = new TH1F("h1","x distribution",100,-4,4);
- h1->Fill(x);
- h1->Draw();

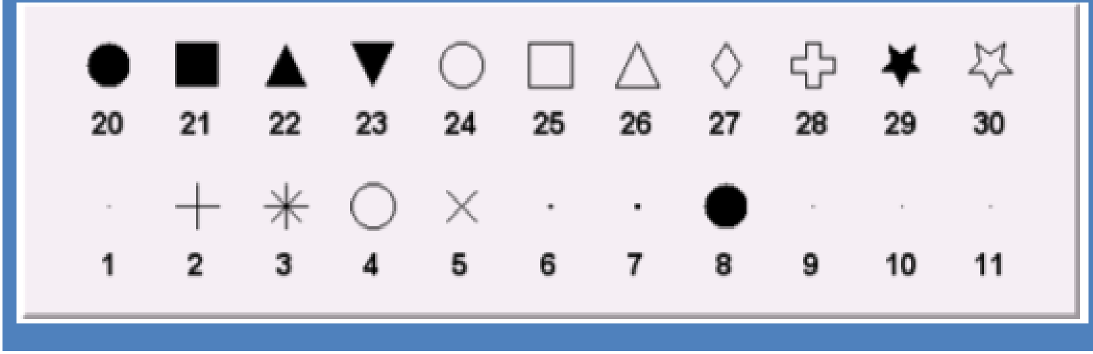


Histogram Properties

Command	Parameters
h1.GetMean()	Mean
h1.GetRMS()	Root of Variance
h1.GetMaximum();	Maximum bin content
h1.GetMaximumBin(int bin_number);	location of maximum
h1.GetBinCenter(int bin_number);	Center of bin
h1.GetBinContent(int bin_number);	Content of bin

Histogram Cosmetics

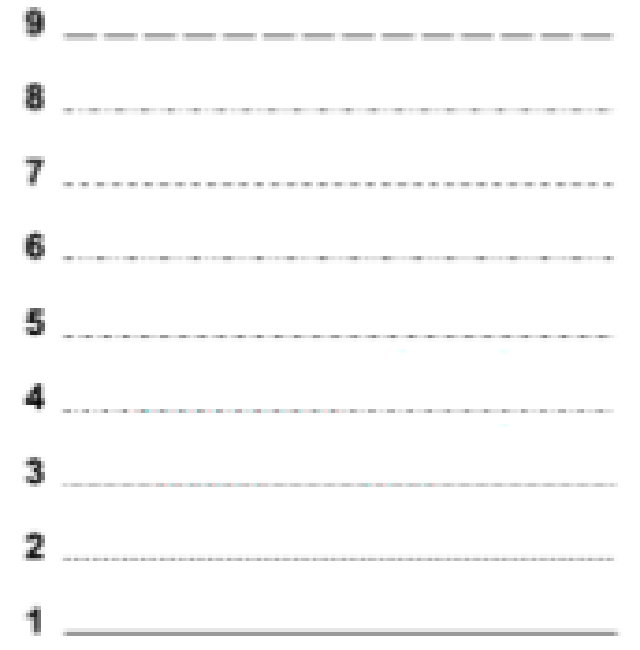
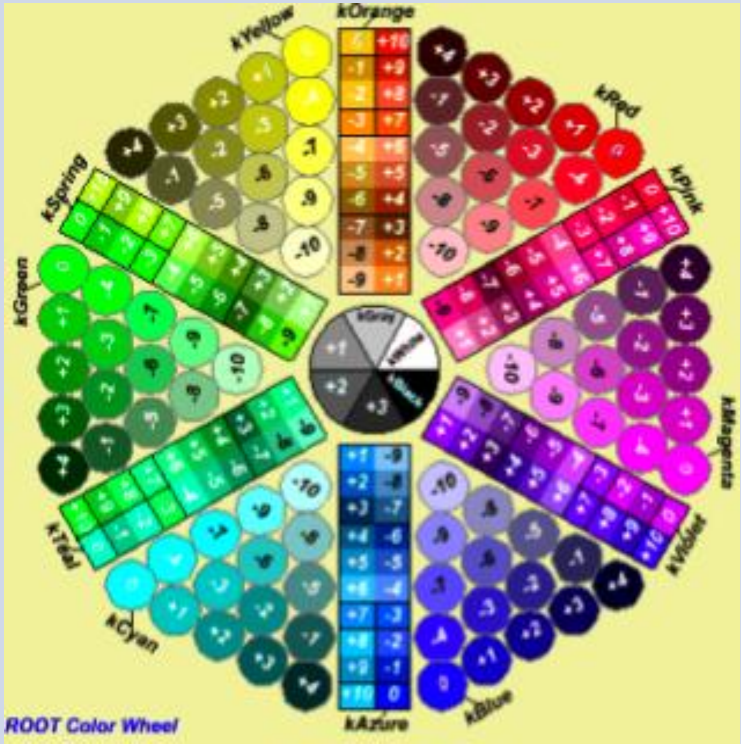
h1.SetMarkerStyle();



h1.SetFillColor();

40	41	42	43	44	45	46	47	48	49
30	31	32	33	34	35	36	37	38	39
20	21	22	23	24	25	26	27	28	29
10	11	12	13	14	15	16	17	18	19
0	1	2	3	4	5	6	7	8	9

Histogram cosmetics: Lines

LineStyle **h1->SetLineStyle();**	**LineColor** **h1.SetLineColor();**
	

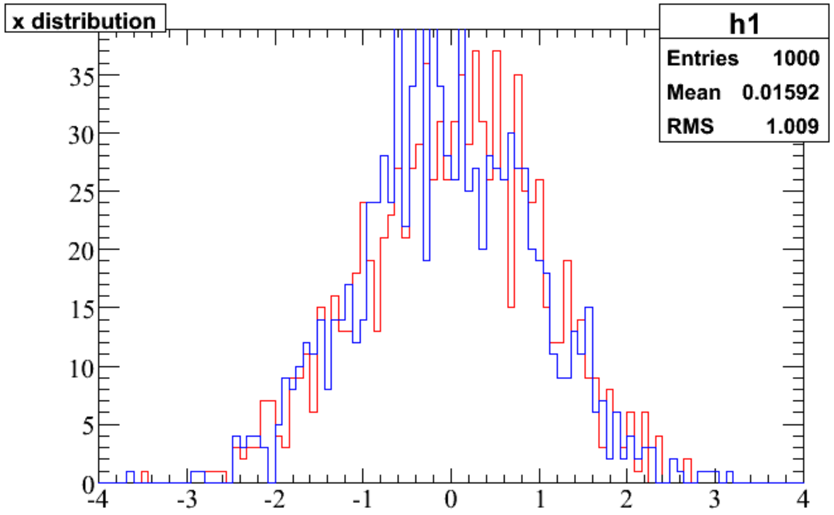
1D Histogram

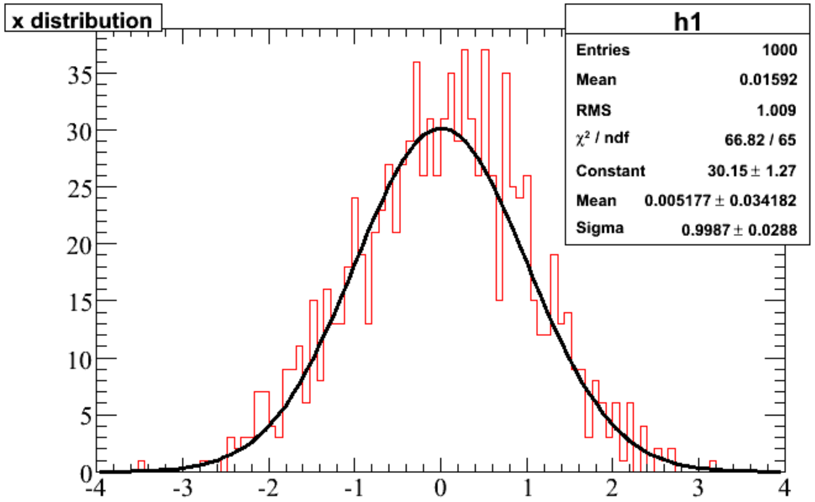
Overlapping

- h1->Draw();
- h2->Draw("same");

Fit (will be covered in detail later)

- h1->Fit("gaus");





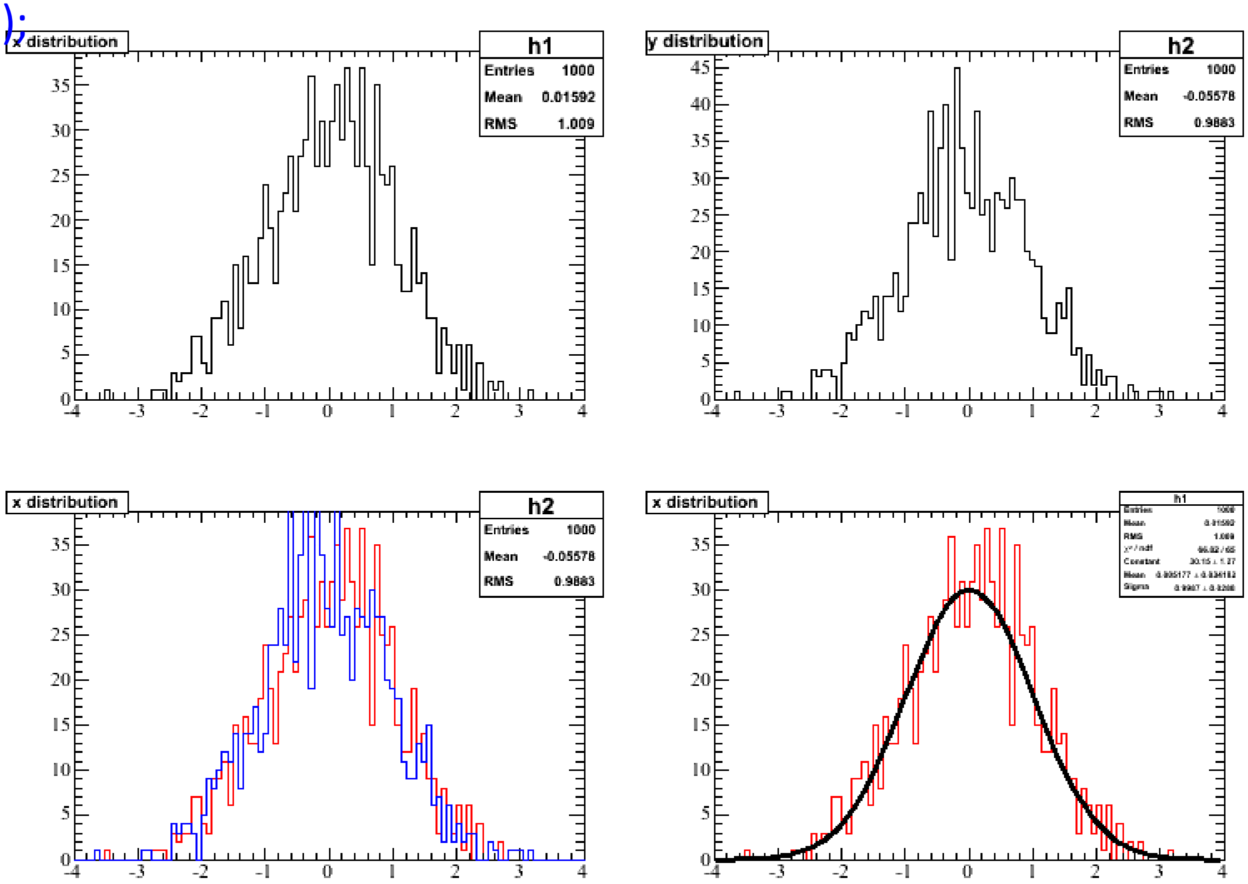
Canvas: an area mapped to a window

Command	Action
c1 = new TCanvas(“c1”,”Title, w, h)	Creates a new canvas with width equal to w number of pixels and height equal to h number of pixels.
c1->Divide(2,2);	Divides the canvas to 4 pads.
c1->cd(3)	Select the 3rd Pad

c1->SetGridx();
c1->SetGridy();
c1->SetLogy();
	You can set grid along x and y axis.
	You can also set log scale plots.

Canvas: Demo…

```
root [1] c1 = new
TCanvas("c1","Title",800,600);
root [2] c1->Divide(2,2);
root [3] c1->cd(1);
root [4] h1->Draw();
root [5] c1->cd(2);
root [6] h2->Draw();
root [7] c1->cd(3);
root [8] h1->SetLineColor(2)
root [9] h2->SetLineColor(4)
root [10] h1->Draw();
root [11] h2->Draw("same");
root [12] c1->cd(4);
root [13] h1->Fit("gaus");
```

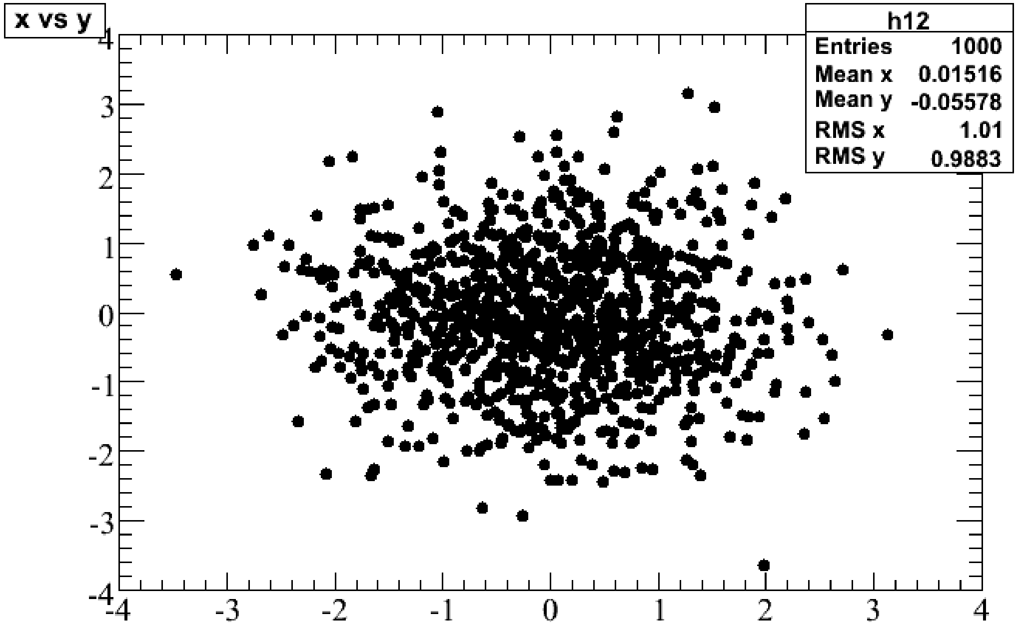


2D Histograms: TH2

- TH2F *name = new TH2F(”name",”Title”, xBins, low xbin, up xbin, yBins, low ybin, up y bin);

Example:

- TH2F *h12 = new TH2F("h12","x vs y",100,-4,4,100, -4, 4);
- h12->Fill(x,y);
- h12->Draw();

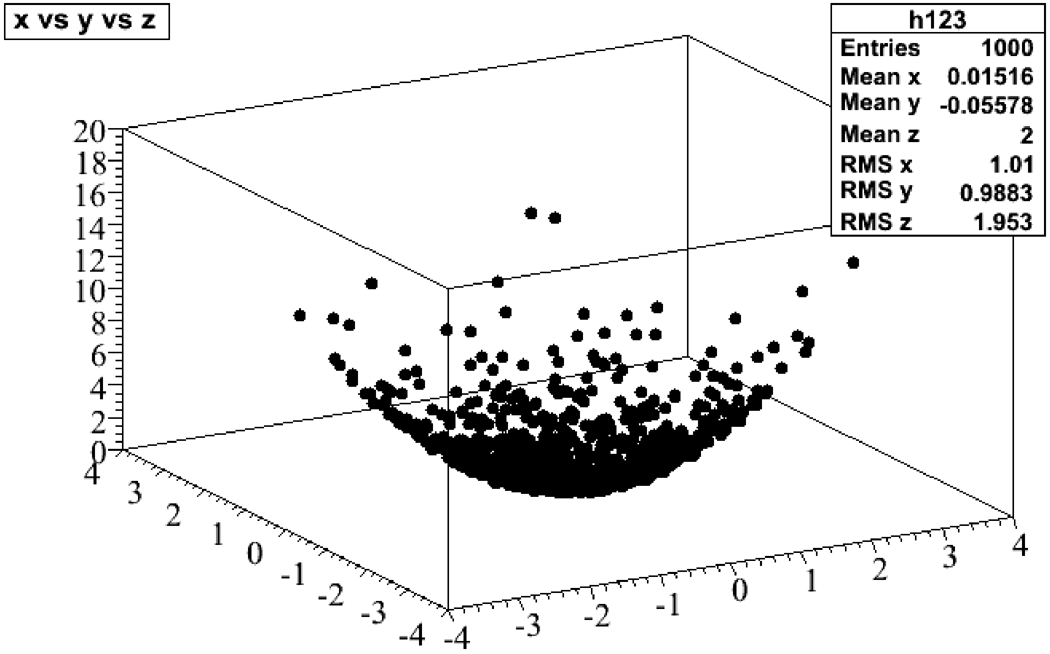


3D Histograms: TH3

- TH3F *name = new TH3F(”name",”Title”, xBins, low xbin, up xbin, yBins, low ybin, up ybin, zBins, low zbin, up zbin);

Example:

- TH3F *h123 = new TH3F("h123","x vs y vs z",100,-4,4,100, -4, 4,100,0,20);
- h123->Fill(x,y,z);
- h123->Draw();



Histogram Drawing Options

" SAME": Superimpose on previous picture in the same pad.

" CYL": Use cylindrical coordinates.

" POL": Use polar coordinates.

" SPH": Use spherical coordinates.

" PSR": Use pseudo-rapidity/phi coordinates.

" LEGO": Draw a lego plot with hidden line removal.

" LEGO1": Draw a lego plot with hidden surface removal.

" LEGO2": Draw a lego plot using colors to show the cell contents.

" SURF": Draw a surface plot with hidden line removal.

" SURF1": Draw a surface plot with hidden surface removal.

" SURF2": Draw a surface plot using colors to show the cell contents.

" SURF3": Same as SURF with a contour view on the top.

" SURF4": Draw a surface plot using Gouraud shading.

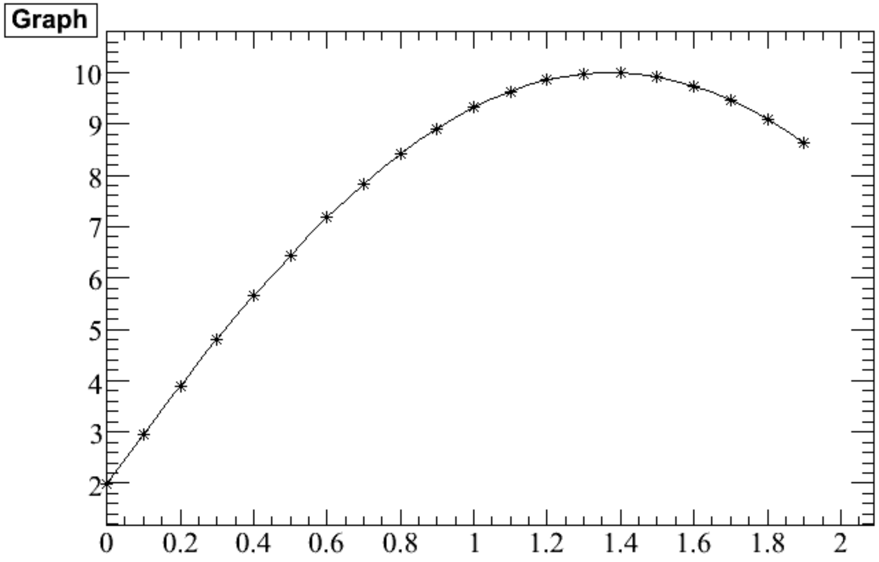
“ SURF5”: Same as SURF3 but only the colored contour is drawn.

Note: Please check chapter 3 in user’s guide to learn more about options.

Graphs

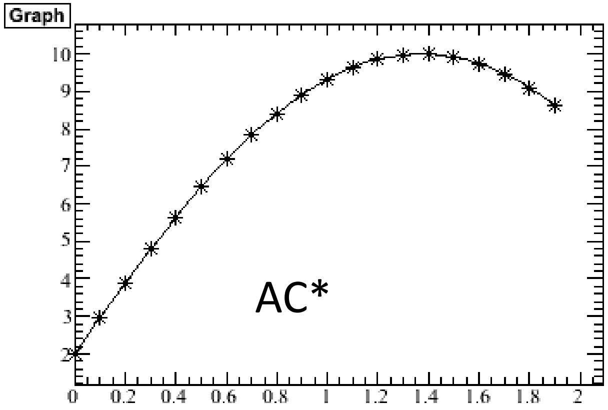
Graphics object made of two arrays X and Y, holding the x, y coordinates of n points

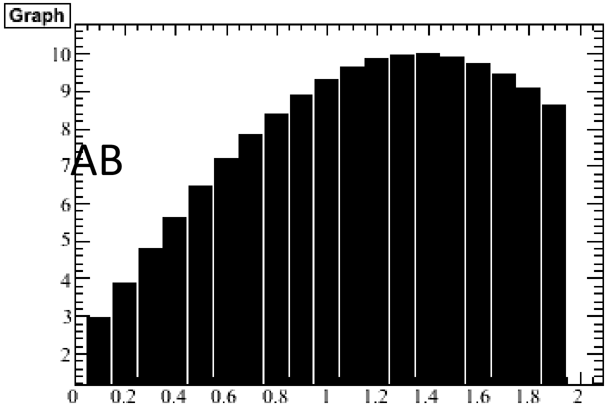
Graphs:

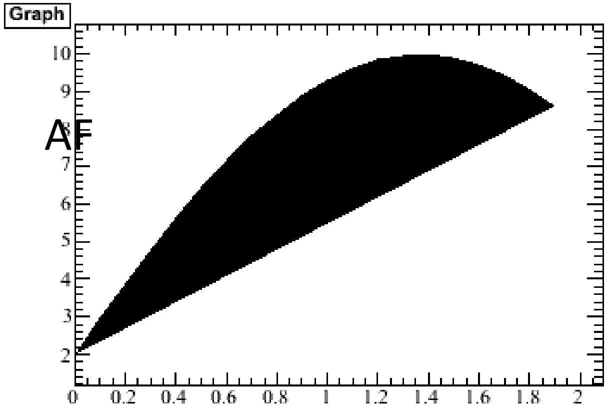


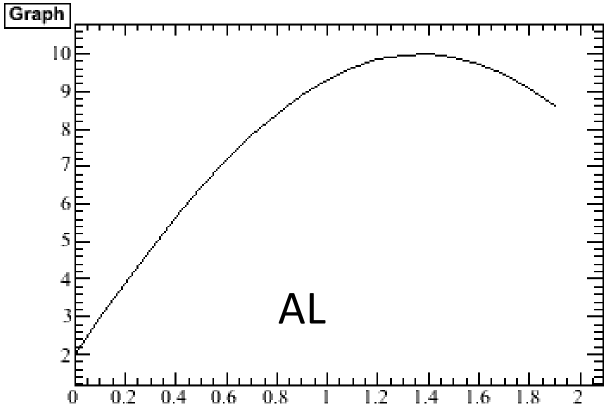
- `Int_t n = 20;`
- `Double_t x[n], y[n];`
- `for (Int_t i=0; i<n; i++){`
- `  x[i] = i*0.1;`
- `  y[i] = 10*sin(x[i]+0.2); }`
- `TGraph *gr1 = new TGraph (n, x, y);`
- `gr1->Draw("AC*");`

Graph Drawing Options

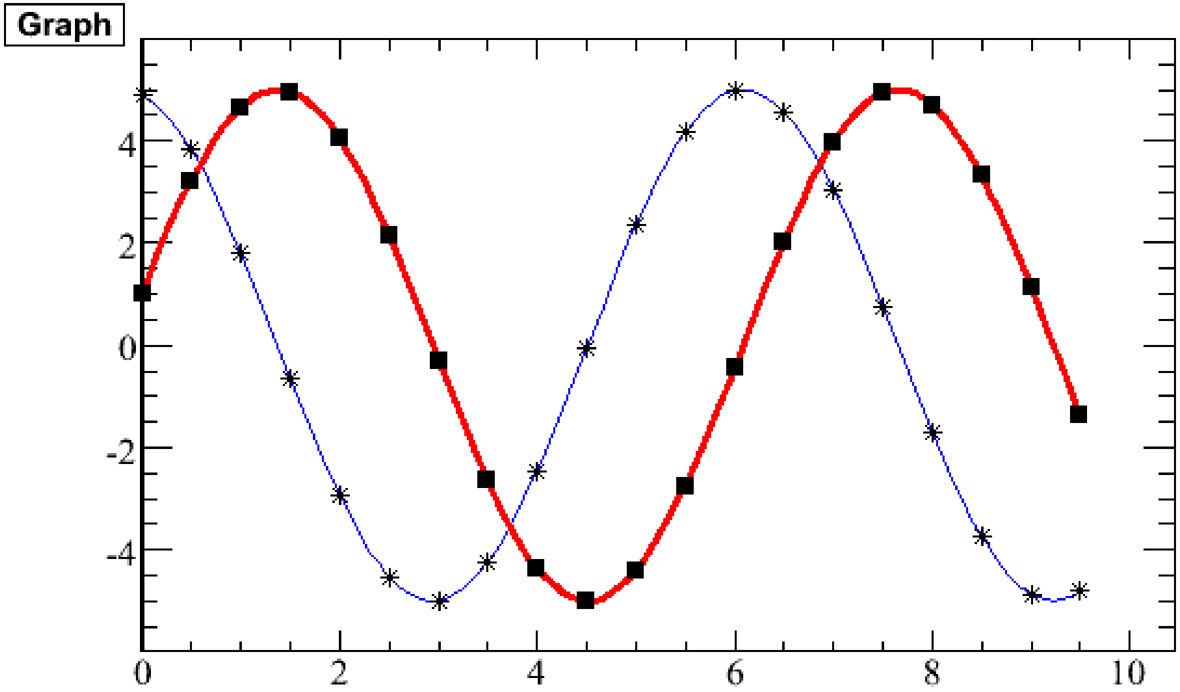








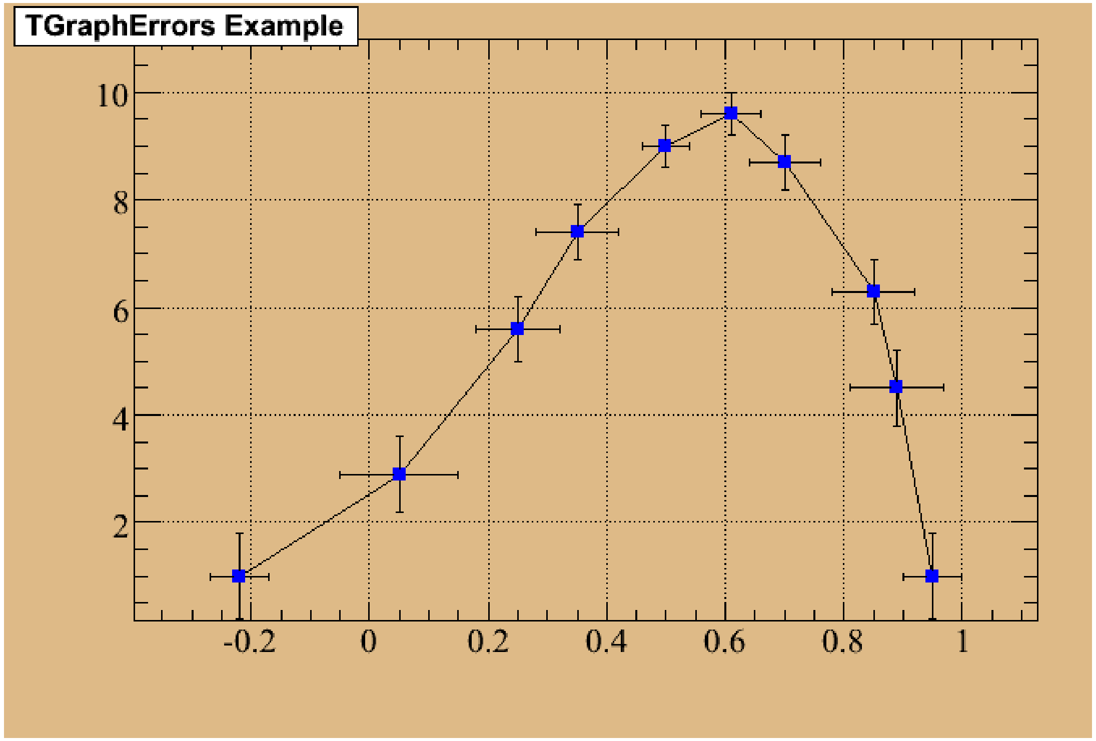
Superimpose two Graphs



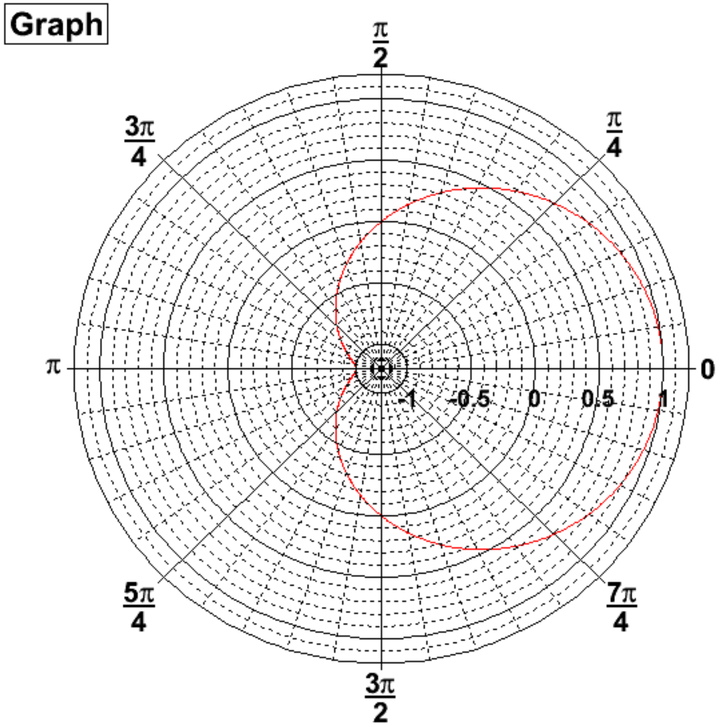
- TGraph *gr1 = new TGraph(n,x,y);
- TGraph *gr2 = new TGraph(n,x1,y1);
- gr1->SetLineColor(4);
- gr1->Draw("AC*");
- gr2->SetLineWidth(3);
- gr2->SetMarkerStyle(21);
- gr2->SetLineColor(2);
- gr2->Draw("CP");

Graph with Error bar

- Float_t x[n] = {-.22,.05,.25,.35,.5,.61,.7,.85,.89,.95};
- Float_t y[n] = {1,2.9,5.6,7.4,9,9.6,8.7,6.3,4.5,1};
- Float_t ex[n] = {.05,.1,.07,.07,.04,.05,.06,.07,.08,.05};
- Float_t ey[n] = {.8,.7,.6,.5,.4,.4,.5,.6,.7,.8};
- gr = new TGraphErrors(n,x,y,ex,ey);



Polar Graphs



- Generate or calculate "r" and "theta"
- TGraphPolar * grP1 = new TGraphPolar(1000,r,theta);
- grP1->Draw();

TTree

Saving data in a table with rows representing the event and columns representing quantities.

ROOT Tree

- Store large quantities of same-class objects
- TTree class is optimized to reduce disk space and enhance access speed
- TTree can hold all kind of data
- TNtuple is a TTree that is limited to only hold floating-point numbers

If we do not use TTree, we need to

- read each event in its entirety into memory
- extract the parameters from the event
- Compute quantities from the same
- fill a histogram

Create a Root TTree/TNtuple

- Tfile *F = new Tfile(“test.root”,RECREATE);
- TTree *T = new TTree("T","test");
- T->Branch("x",&x,"x/F");
- T->Branch("y",&y,"x/F");
- T->Branch("z",&z,"x/F");

// Read/or calculate x,y and z

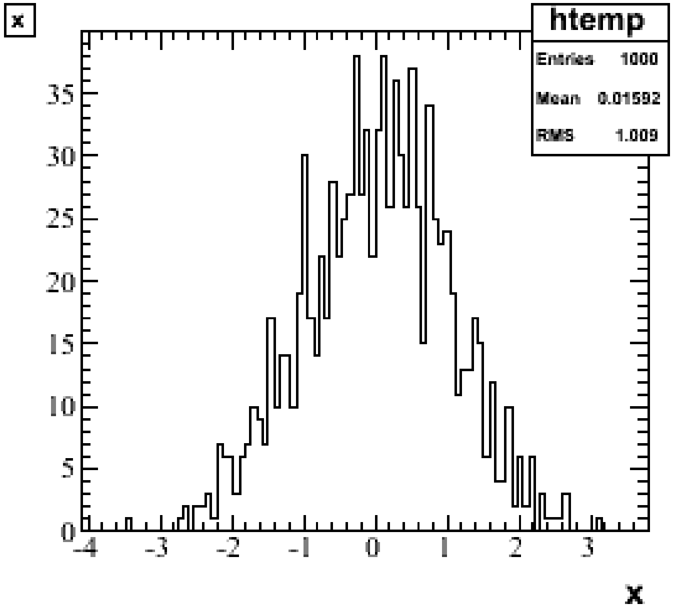
- T->Fill();
- T->Close();
- F->Close();

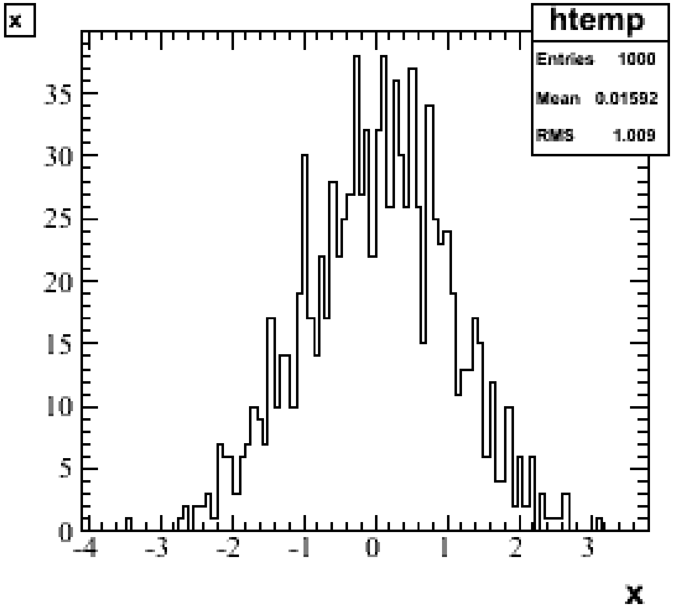
- Tfile *F = new Tfile(“test.root”,RECREATE);
- TNtuple *T = new TNtuple("ntuple","data from ascii file","x:y:z");

// Read/or calculate x,y and z

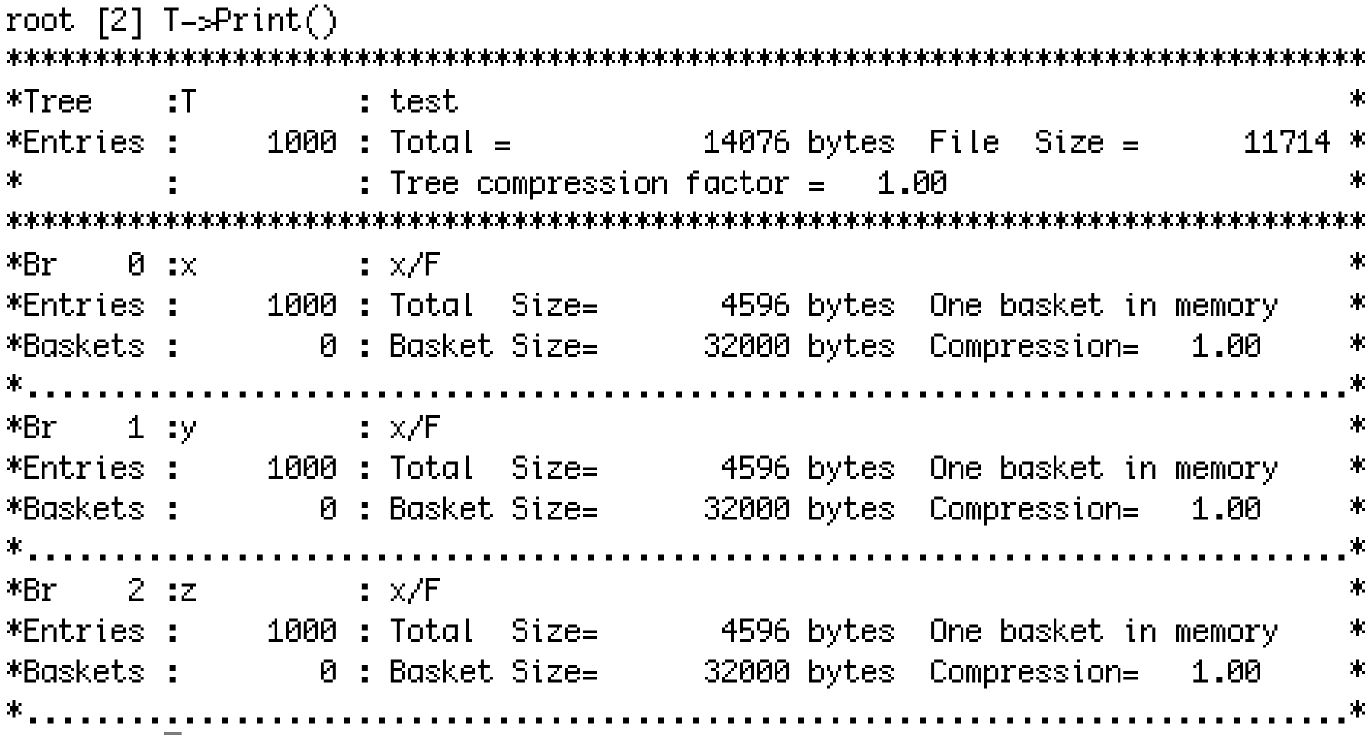
- T->Fill(x,y,z);
- T->Close();
- F->Close();

Draw: T->Draw(“x”);



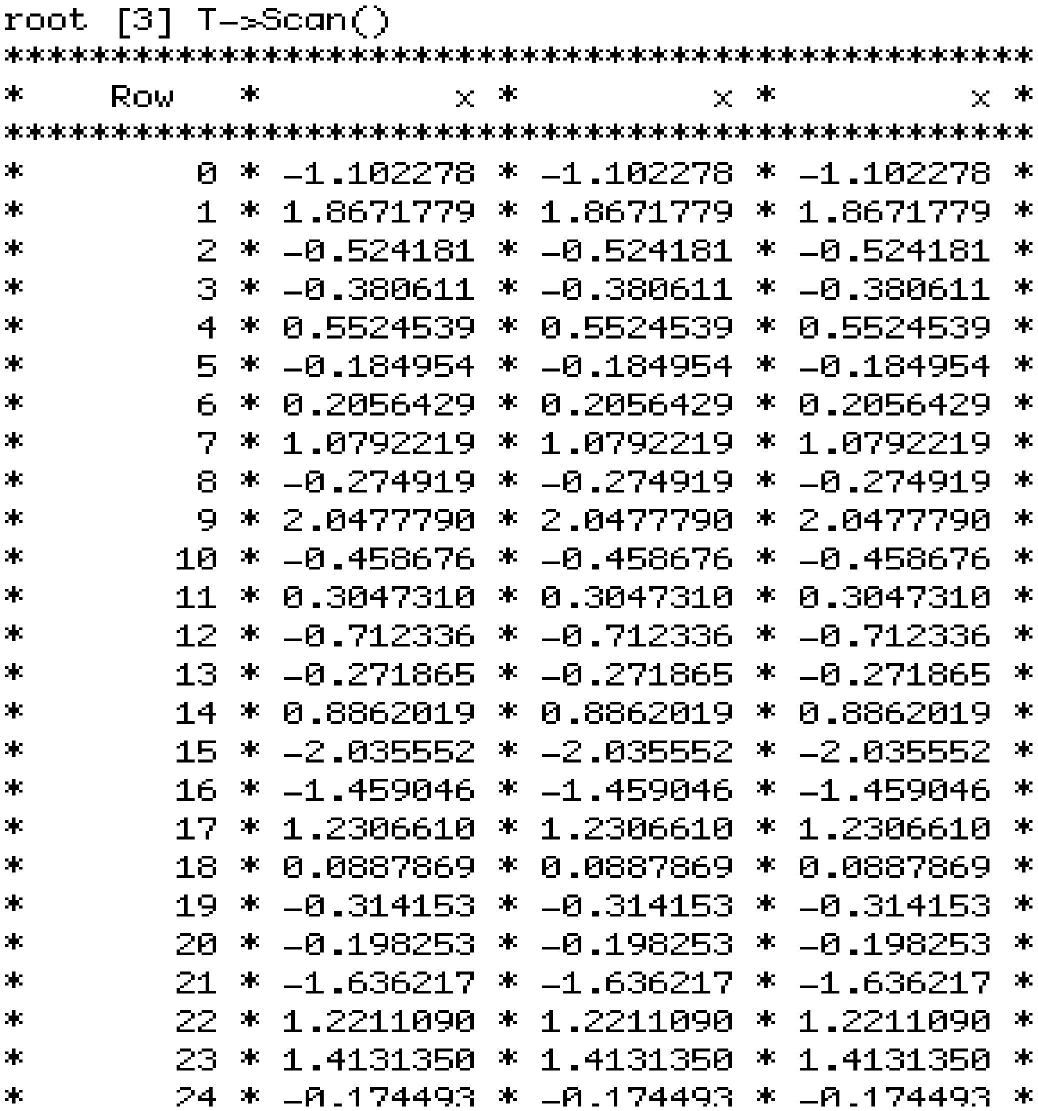


T->Print(); //Print the Root Content



```
root [2] T->Print()
******************************************************************************
*Tree    :T         : test                                                   *
*Entries :     1000 : Total =           14076 bytes  File  Size =      11714 *
*        :          : Tree compression factor =   1.00                       *
******************************************************************************
*Br    0 :x         : x/F                                                    *
*Entries :     1000 : Total  Size=       4596 bytes  One basket in memory    *
*Baskets :        0 : Basket Size=      32000 bytes  Compression=   1.00     *
*............................................................................*
*Br    1 :y         : x/F                                                    *
*Entries :     1000 : Total  Size=       4596 bytes  One basket in memory    *
*Baskets :        0 : Basket Size=      32000 bytes  Compression=   1.00     *
*............................................................................*
*Br    2 :z         : x/F                                                    *
*Entries :     1000 : Total  Size=       4596 bytes  One basket in memory    *
*Baskets :        0 : Basket Size=      32000 bytes  Compression=   1.00     *
*............................................................................*
```

T->Scan();//scan the Root rows and columns

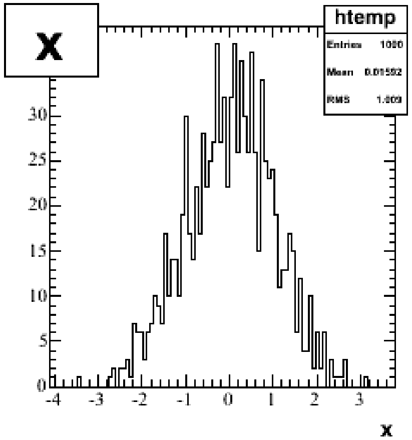


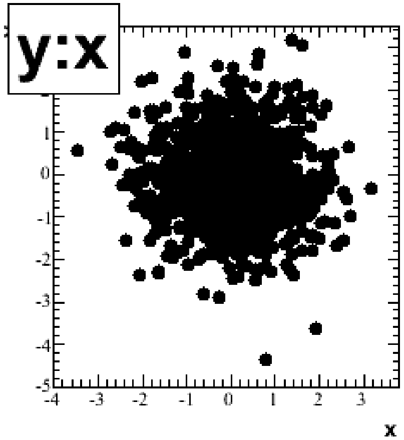
```
root [3] T->Scan()
************************************************
*    Row   *         x *         x *         x *
************************************************
*        0 * -1.102278 * -1.102278 * -1.102278 *
*        1 * 1.8671779 * 1.8671779 * 1.8671779 *
*        2 * -0.524181 * -0.524181 * -0.524181 *
*        3 * -0.380611 * -0.380611 * -0.380611 *
*        4 * 0.5524539 * 0.5524539 * 0.5524539 *
*        5 * -0.184954 * -0.184954 * -0.184954 *
*        6 * 0.2056429 * 0.2056429 * 0.2056429 *
*        7 * 1.0792219 * 1.0792219 * 1.0792219 *
*        8 * -0.274919 * -0.274919 * -0.274919 *
*        9 * 2.0477790 * 2.0477790 * 2.0477790 *
*       10 * -0.458676 * -0.458676 * -0.458676 *
*       11 * 0.3047310 * 0.3047310 * 0.3047310 *
*       12 * -0.712336 * -0.712336 * -0.712336 *
*       13 * -0.271865 * -0.271865 * -0.271865 *
*       14 * 0.8862019 * 0.8862019 * 0.8862019 *
*       15 * -2.035552 * -2.035552 * -2.035552 *
*       16 * -1.459046 * -1.459046 * -1.459046 *
*       17 * 1.2306610 * 1.2306610 * 1.2306610 *
*       18 * 0.0887869 * 0.0887869 * 0.0887869 *
*       19 * -0.314153 * -0.314153 * -0.314153 *
*       20 * -0.198253 * -0.198253 * -0.198253 *
*       21 * -1.636217 * -1.636217 * -1.636217 *
*       22 * 1.2211090 * 1.2211090 * 1.2211090 *
*       23 * 1.4131350 * 1.4131350 * 1.4131350 *
*       24 * -0.174493 * -0.174493 * -0.174493 *
```

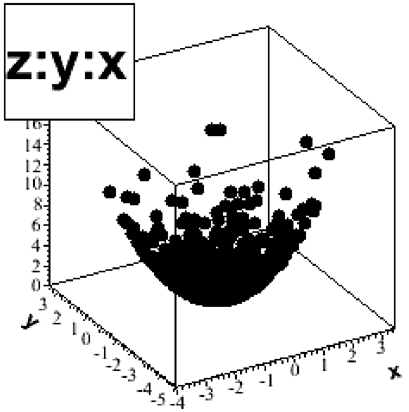
Play with Root Tree

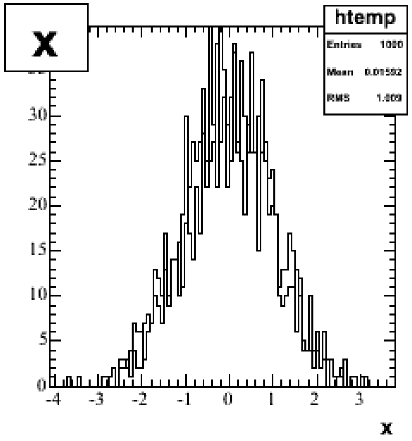
Command	**Action**
T->Print();	Prints the content of the tree
T->Scan();	Scans the rows and columns
T->Draw(“x”);	Draw a branch of tree
How to apply cuts: T->Draw(“x”,”x>0”); T->Draw(“x”,”x>0 && y>0”);	Draw “x” when “x>0” Draw “x” when both x >0 and y >0
T->Draw(“y”,” “,”same”);	Superimpose “y” on “x”
T->Draw(“y:x”);	Make “y vs x” 2d scatter plot
T->Draw(“z:y:x”);	Make “z:y:x” 3d plot
T->Draw(“sqrt(x*x+y*y)”);	Plot calculated quantity
T->Draw(“x>>h1”);	Dump a root branch to a histogram

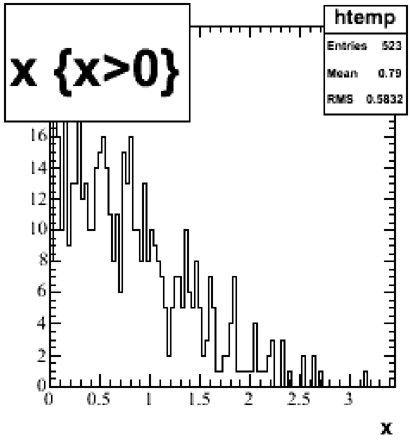
Play with Root Tree

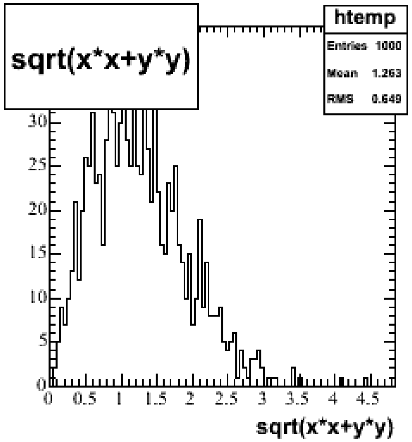






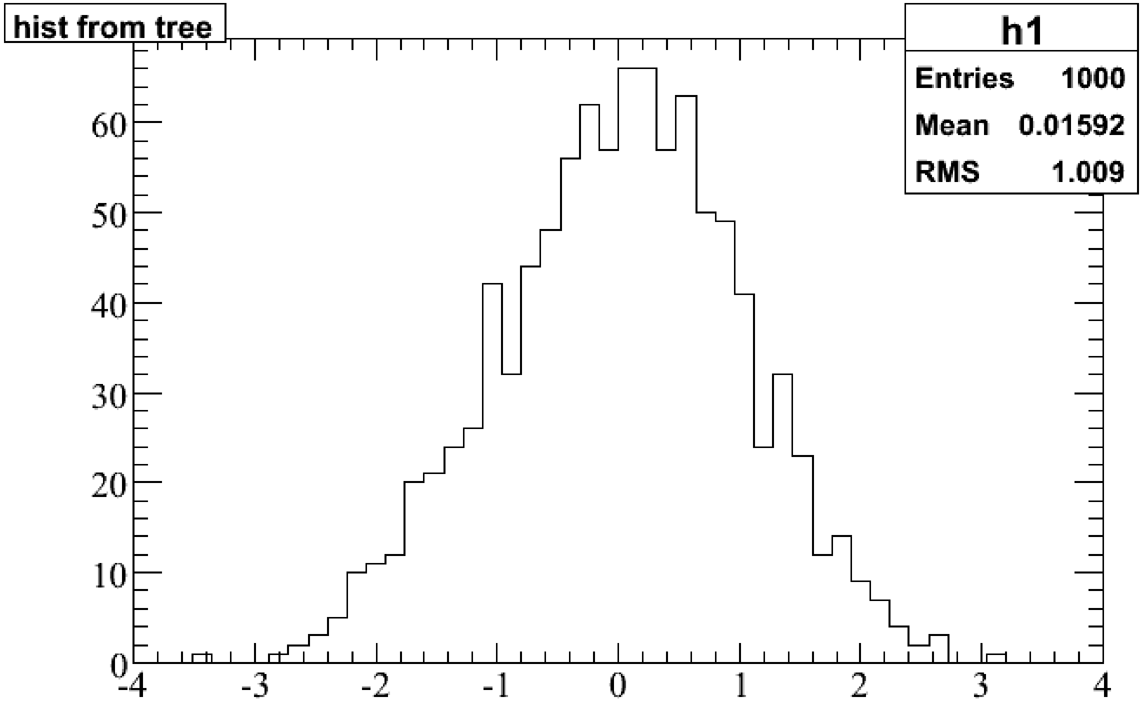






Create Histogram from Root Tree

- root [2] TH1F *h1 = new TH1F("h1","hist from tree",50, -4, 4);
- root [3] T->Draw("x>>h1");



How to deal with number of large Root files with same trees ?

- TChain chain("T");   // name of the tree is the argument
- chain.Add("file1.root");
- chain.Add("file2.root");
- chain.Add("file3.root”);

You can draw “x” from all the files in the chain at the same time

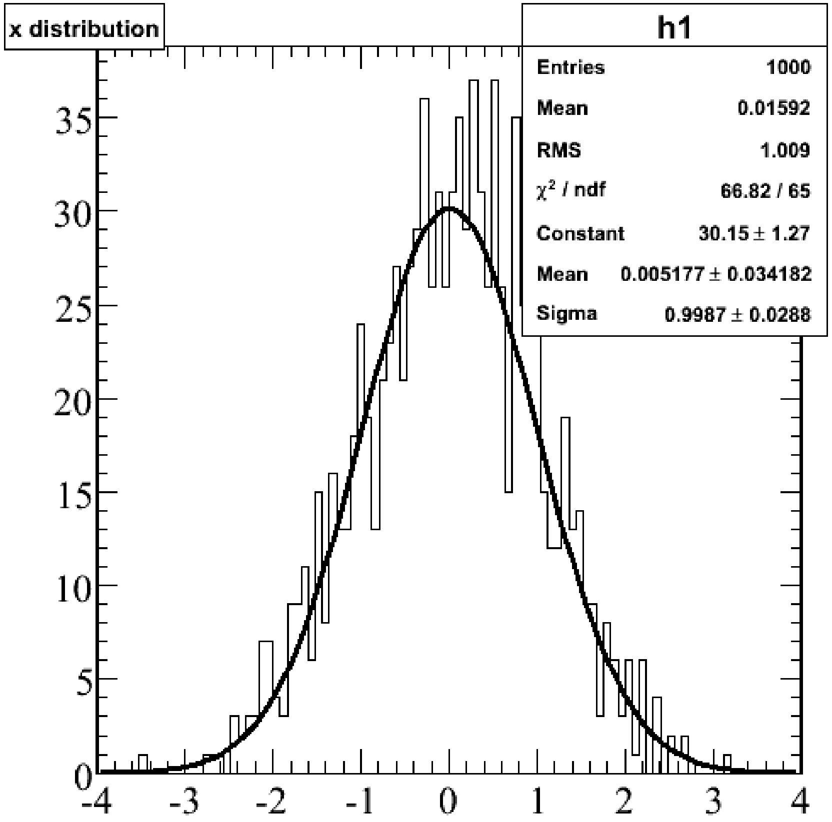
- chain.Draw("x");

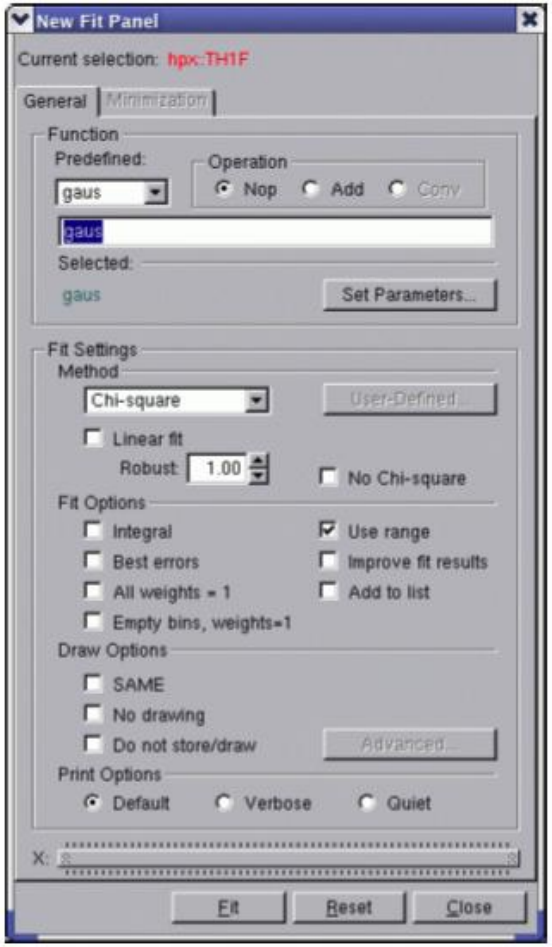
Fitting Histograms in Root

Histograms (1-D,2-D,3-D and Profiles) can be fitted with a user specified function via TH1::Fit.

It uses MINUIT as the minimization routine for fitting,

Fitting Histogram with Fit Panel




New Fit Panel

Current selection: hpx::TH1F

General | Minimization

Function

Predefined: gaus

Operation: ● Nop ○ Add ○ Conv

gaus

Selected: gaus

Set Parameters...

Fit Settings

Method: Chi-square

User-Defined...

☐ Linear fit

Robust: 1.00

☐ No Chi-square

Fit Options

☐ Integral

☑ Use range

☐ Best errors

☐ Improve fit results

☐ All weights = 1

☐ Add to list

☐ Empty bins, weights=1

Draw Options

☐ SAME

☐ No drawing

☐ Do not store/draw

Advanced...

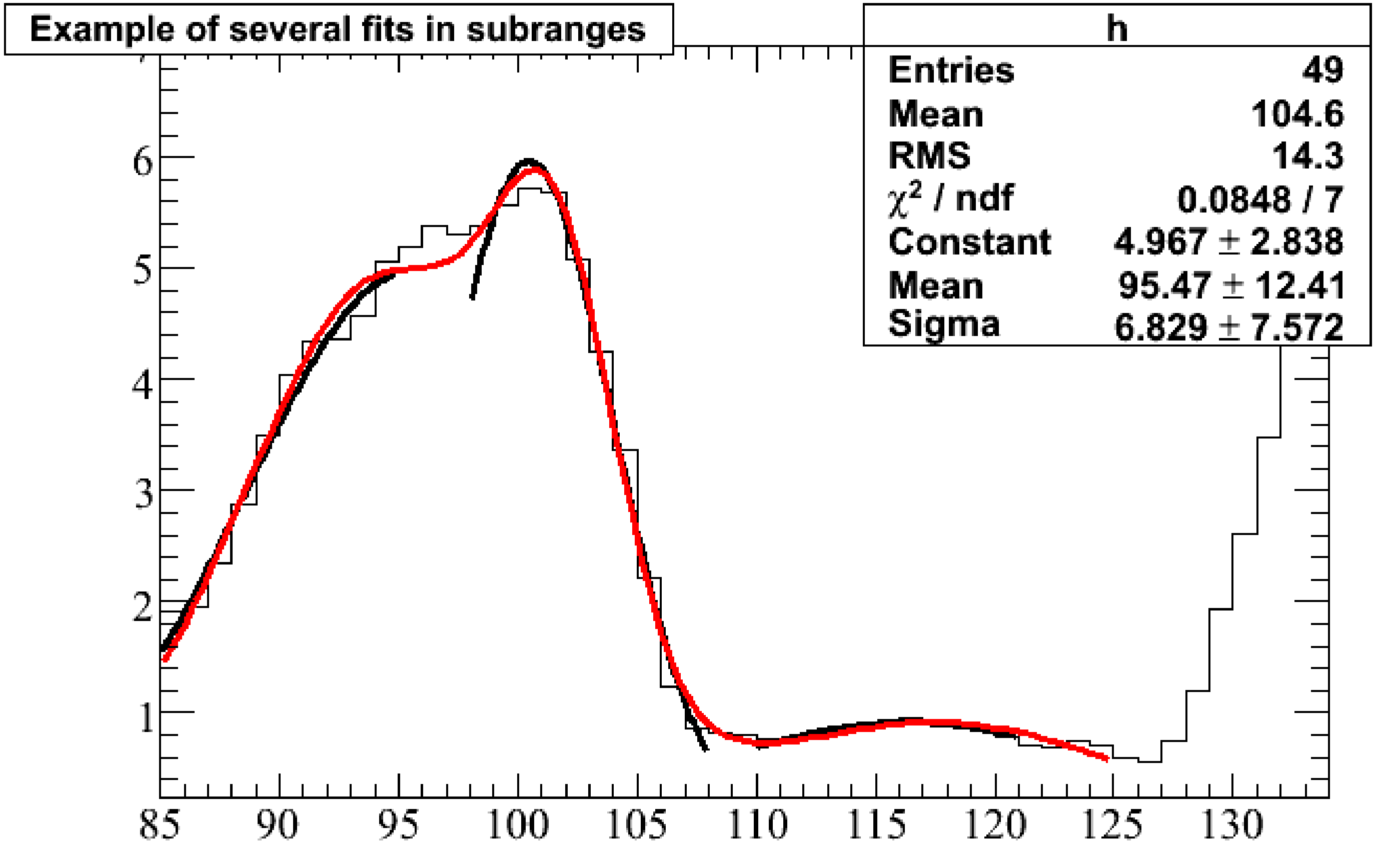
Print Options: ● Default ○ Verbose ○ Quiet

X:

Fit | Reset | Close

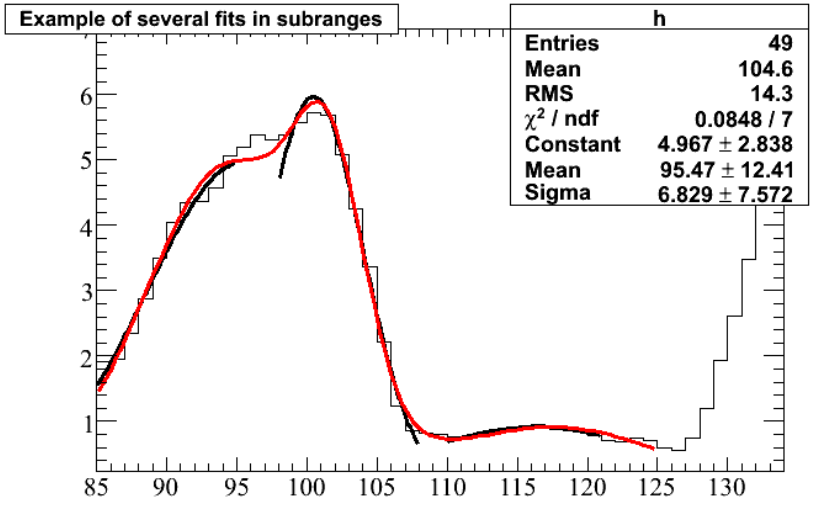
Same as: h1->Fit(“gaus”);

Fitting Multiple Sub Ranges

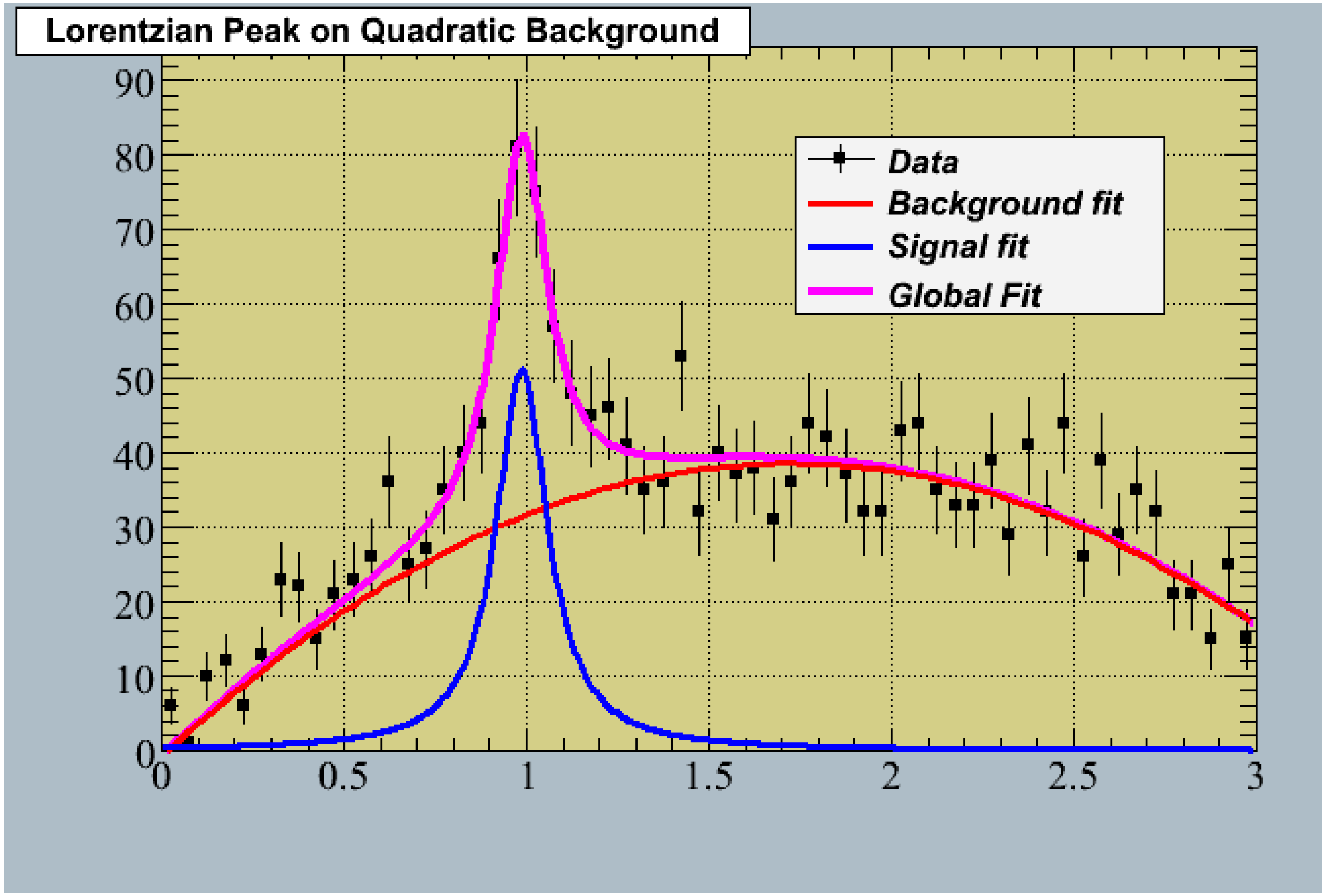


Fitting Multiple Sub Ranges contd.

- `Double_t par[9];`
- `TF1 *g1    = new TF1("g1","gaus",85,95);`
- `TF1 *g2    = new TF1("g2","gaus",98,108);`
- `TF1 *g3    = new TF1("g3","gaus",110,121);`
- `TF1 *total = new TF1("total","gaus(0)+gaus(3)+gaus(6)",85,125);`
- `total->SetLineColor(2);`
- `h->Fit(g1,"R");`
- `h->Fit(g2,"R+");`
- `h->Fit(g3,"R+");`
- `g1->GetParameters(&par[0]);`
- `g2->GetParameters(&par[3]);`
- `g3->GetParameters(&par[6]);`
- `total->SetParameters(par);`
- `h->Fit(total,"R+");`

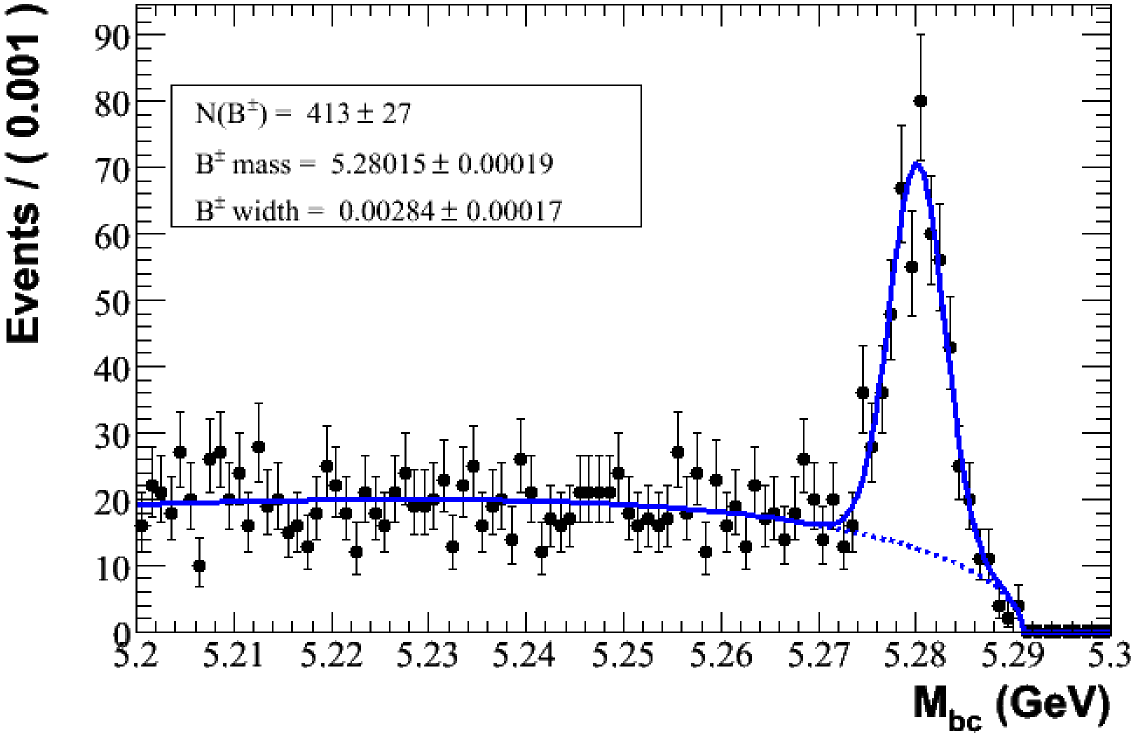


Fitting with Combining Functions



Fitting with RooFit (http://roofit.sourceforge.net/)

- RooFit packages provide a toolkit for modeling the expected distribution of events in a physics analysis
- Models can be used to perform likelihood fits, produce plots, and generate "toy Monte Carlo" samples for various studies



Next Lecture
Analysis of Muon Calibration Simulation Data with ROOT