

# Computing and Statistical Data Analysis

## Some slides about ROOT

Interactive data analysis program and class library.

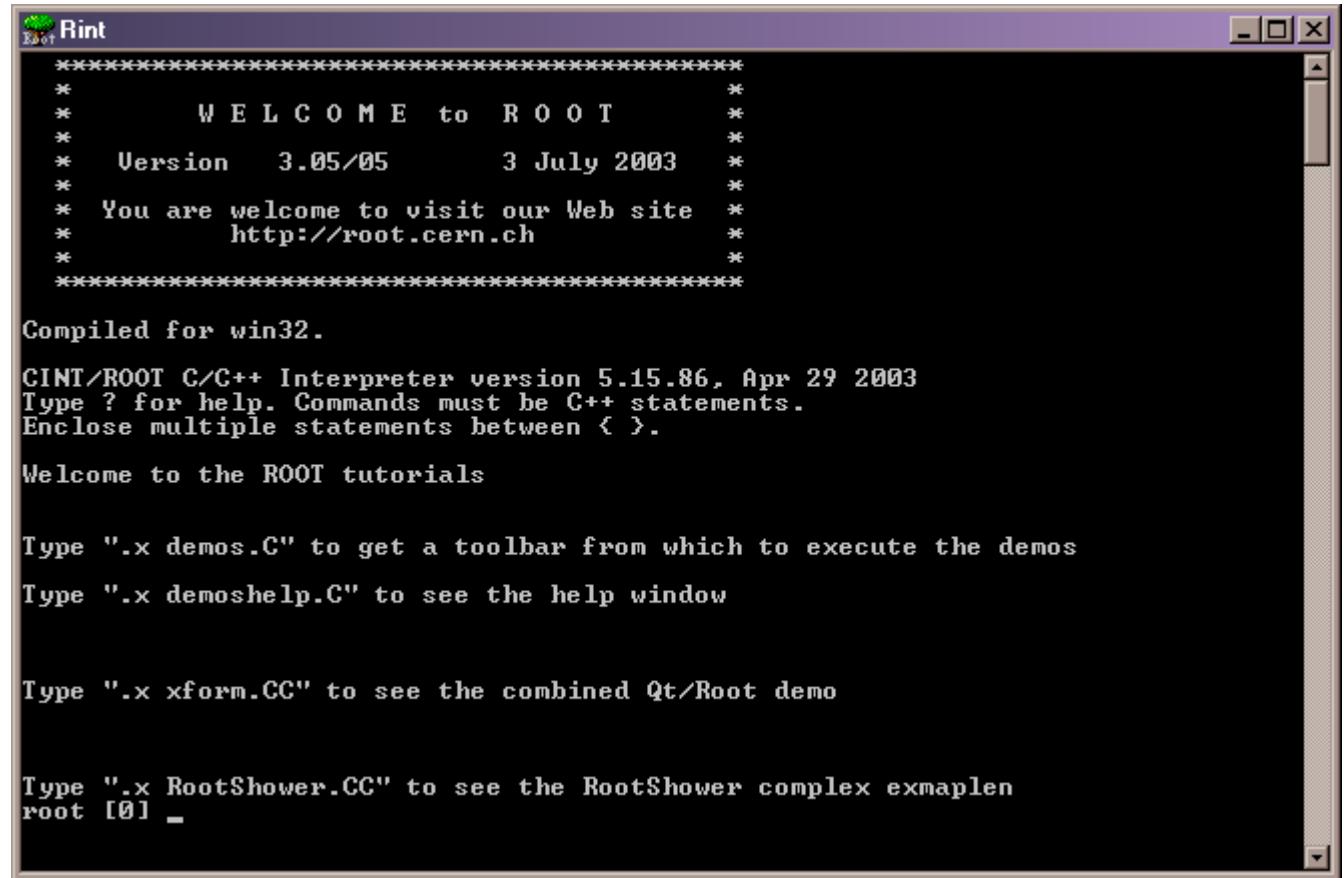
Commands based on C++ (CINT interpreter).

Home page: `root.cern.ch`

Many tutorials, e.g. google for ROOT tutorial

See course web page for stand-alone C++ programs that use ROOT classes, e.g., for histograms.

# Run the program



```
Root Rint
*****
*           W E L C O M E  t o  R O O T           *
*           *           *           *           *
*   Version   3.05/05           3 July 2003       *
*           *           *           *           *
*   You are welcome to visit our Web site        *
*           http://root.cern.ch                   *
*           *           *           *           *
*****

Compiled for win32.

CINT/ROOT C/C++ Interpreter version 5.15.86, Apr 29 2003
Type ? for help. Commands must be C++ statements.
Enclose multiple statements between { }.

Welcome to the ROOT tutorials

Type ".x demos.C" to get a toolbar from which to execute the demos
Type ".x demoshelp.C" to see the help window

Type ".x xform.CC" to see the combined Qt/Root demo

Type ".x RootShower.CC" to see the RootShower complex exmaplen
root [0] _
```

Installation and set up non-trivial. See your local expert.

To run, type **root**

# Run the demo program

Try typing this  
stuff in yourself.

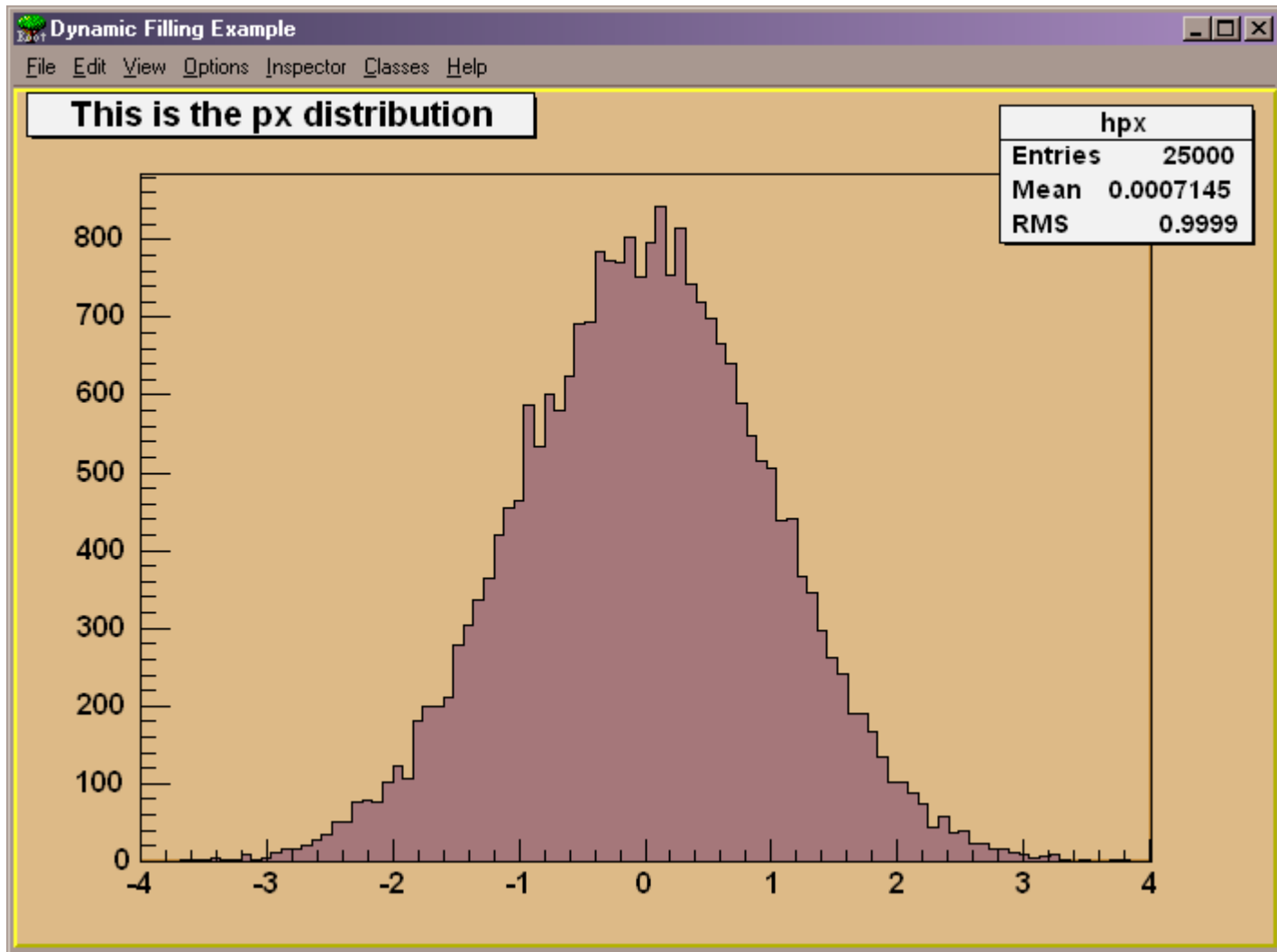
**My first ROOT interactive session**

ROOT is based on CINT, a powerful C/C++ interpreter.  
Blocks of lines can be entered within {...}.  
Previous typed lines can be recalled.

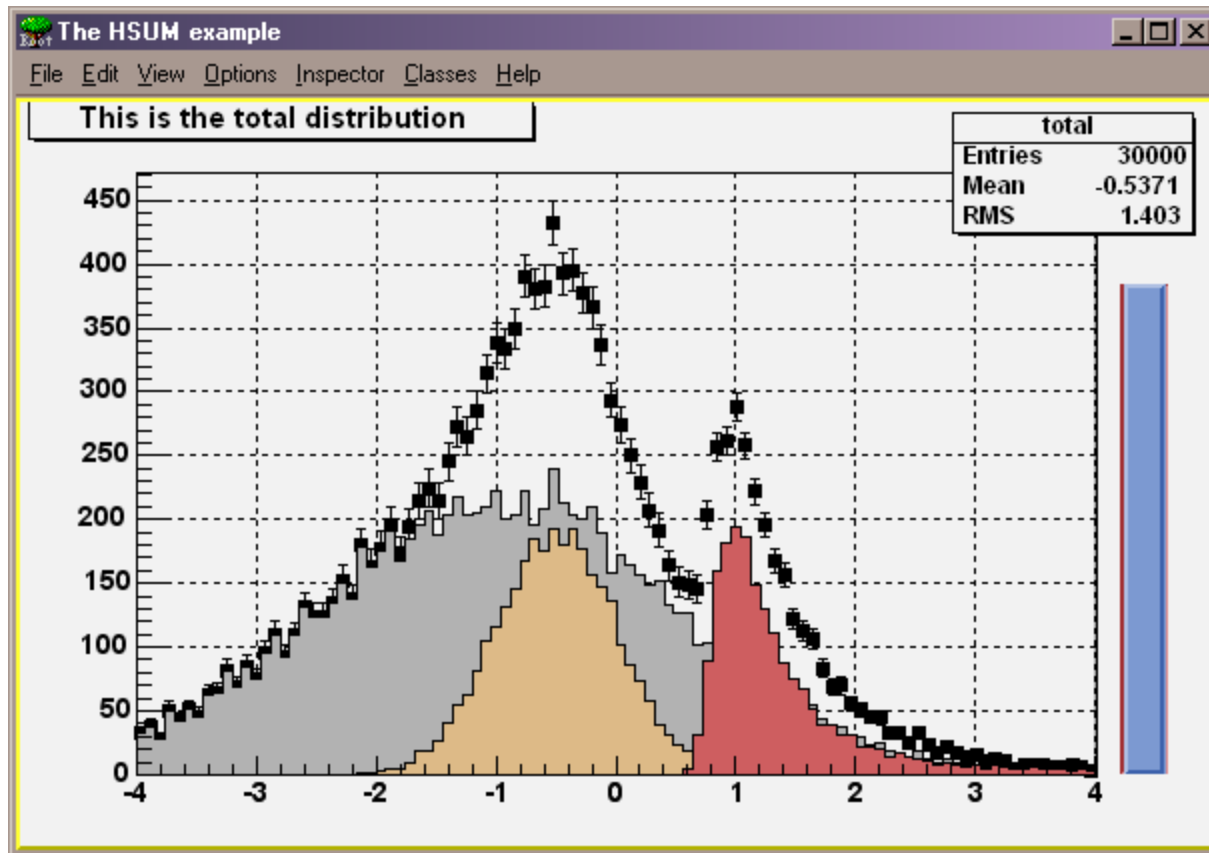
```
Root > float x=5; float y=7;
Root > x*sqrt(y)
(double)1.322875655532e+01
Root > for (int i=2;i<7;i++) printf("sqrt(%d) = %f",i,sqrt(i));
sqrt(2) = 1.414214
sqrt(3) = 1.732051
sqrt(4) = 2.000000
sqrt(5) = 2.236068
sqrt(6) = 2.449490
Root > TF1 f1("f1","sin(x)/x",0,10)
Root > f1.Draw()
```

The plot window shows the function  $\sin(x)/x$  plotted against  $x$  from 0 to 10. The y-axis ranges from -0.2 to 1.0. The curve starts at (0, 1), crosses the x-axis at approximately  $x=3.14$ , reaches a minimum at approximately  $x=4.7$ , and then oscillates with decreasing amplitude.

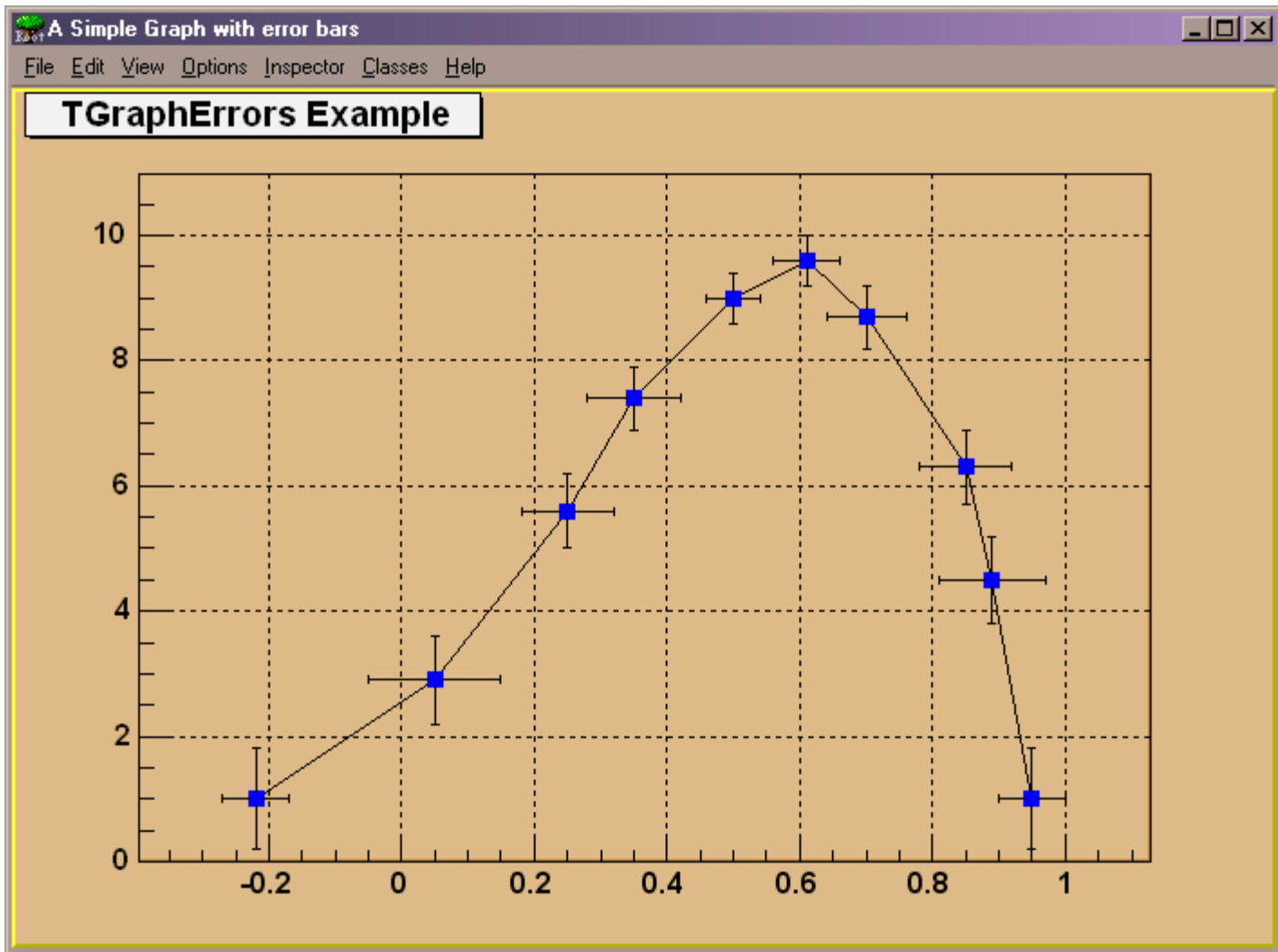
# Book, fill, display a histogram



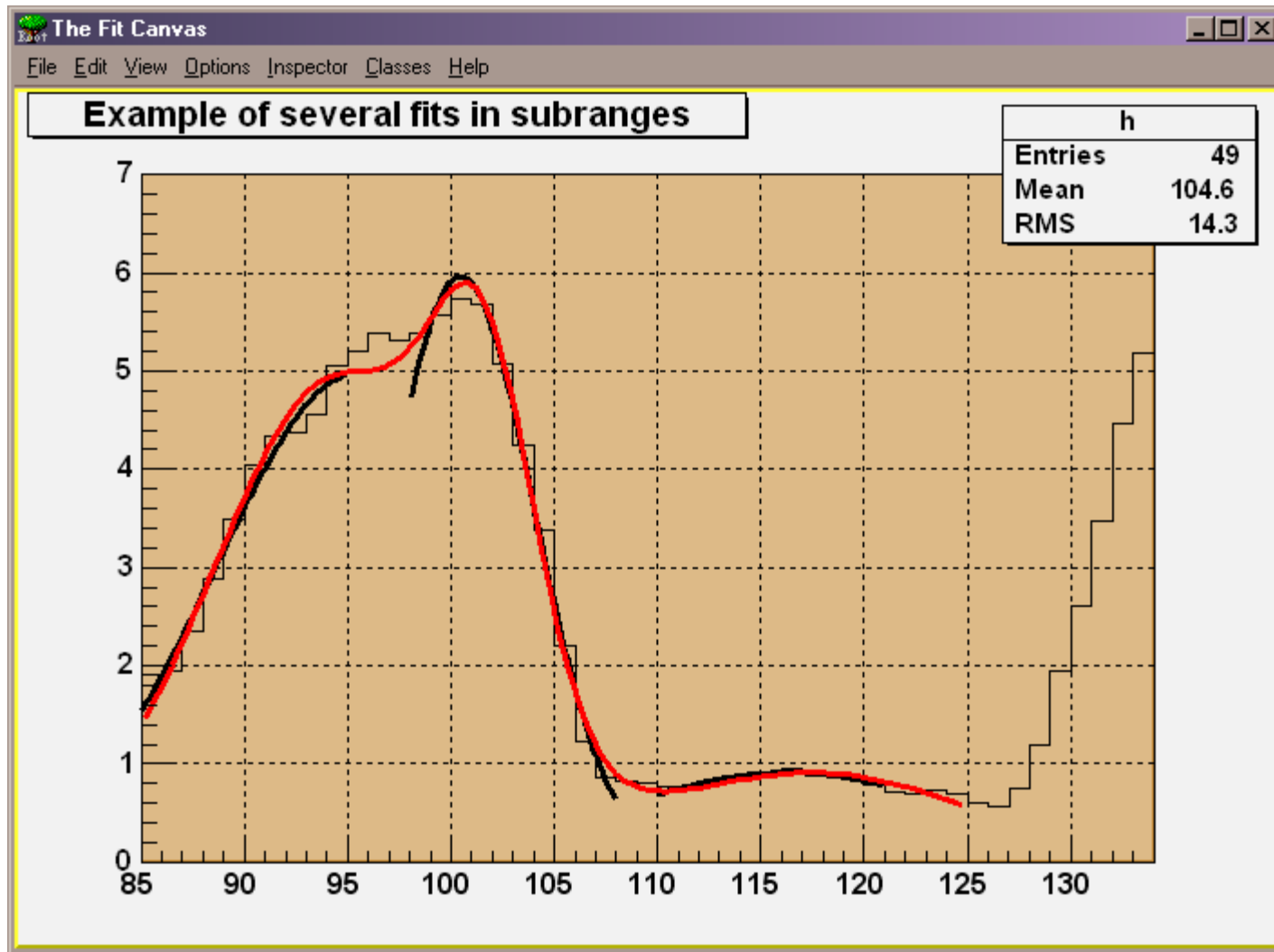
# Fancy stuff with histograms



# Plot a graph with error bars



# Function minimization for fitting



# Working with ROOT

In this course we will write stand-alone C++ programs that use classes from the ROOT library.

Often the program will create histograms (or n-tuples), that we store in a root file (e.g. `myHistogramFile.root`) and we can use the ROOT executable program to analyze these.

To work with ROOT classes, e.g., to know what member functions are available, check the class definition on the web.

You can either find the documentation on `root.cern.ch` or google for the class name (ROOT classes always start with **T**, e.g., `TFile`, `TRandom`,...)



# Googling for ROOT class name usually quickest

TFile - Google Search - Windows Internet Explorer

http://www.google.co.uk/search?hl=en&q=TFile&meta=

Google

Web Images News Maps <sup>New!</sup> Products Groups Scholar [more »](#)

TFile Search [Advanced Search](#) [Preferences](#)

Search:  the web  pages from the UK

**Web** Results 1 - 10 of about 405,000 for TFile.

**TFile**  
To open non-local files use the static **TFile::Open()** method, that will take care of opening the files using the correct remote file access plugin. ...  
[root.cern.ch/root/html/TFile.html](http://root.cern.ch/root/html/TFile.html) - 195k - [Cached](#) - [Similar pages](#)

**TFile**  
Array of pointers to TProcessIDs static Double\_t fgBytesWrite Number of bytes written by all TFile objects static Double\_t fgBytesRead Number of bytes read ...  
[root.cern.ch/root/html302/TFile.html](http://root.cern.ch/root/html302/TFile.html) - 58k - [Cached](#) - [Similar pages](#)  
[ [More results from root.cern.ch](#) ]

**Торрент-трекер tfile.ru**- [ [Translate this page](#) ]  
быстрый торрент трекер Список форумов **tfile.ru** ... Добро пожаловать на сайт **tfile.ru** - русскоязычную файлообменную BitTorrent сеть ...  
[tfile.ru/](http://tfile.ru/) - 155k - [Cached](#) - [Similar pages](#)

**TFILE**  
When you activate a text frame for text capture, the text frame number appears in the TFILE field on the right end of the status bar. ...  
[www.unidata.ucar.edu/software/mcidas/2004/users\\_guide/TFILE.html](http://www.unidata.ucar.edu/software/mcidas/2004/users_guide/TFILE.html) - 6k -

# Sample program `simpleMC.cc`

Below is a stand alone C++ program that uses ROOT classes for random numbers and histograms:

```
#include <TH1D.h>
#include <TFile.h>
#include <TRandom3.h>

using namespace std;

int main(){

// Open output file

    TFile* file = new TFile("simpleMC.root", "recreate");

// Book histograms

    TH1D* h_Uni = new TH1D("h_Uni", "uniform random numbers", 100, 0, 1.0);
    TH1D* h_Exp = new TH1D("h_Exp", "exponential random numbers", 100, 0, 5.0);
```

title

# of bins

bin limits

## simpleMC.cc (2)

```
// Create a TRandom3 object to generate random numbers

int seed = 12345;
TRandom3* ran = new TRandom3(seed);

// Generate some random numbers and fill histograms

const int numValues = 10000;
const double xi = 1.0;           // mean of exponential pdf

for (int i=0; i<numValues; ++i){
    double r = ran->Rndm();       // uniform in ]0,1]
    double x = - xi * log(r);
    h_Uni->Fill(r);
    h_Exp->Fill(x);
}

// Store all histograms in the output file and close up

file->Write();
file->Close();

return 0;
}
```

# GNUmakefile to build simpleMC

```
PROGNAME      = simpleMC
SOURCES       = simpleMC.cc
INCLUDES      =
OBJECTS       = $(patsubst %.cc, %.o, $(SOURCES))
ROOTCFLAGS    := $(shell root-config --cflags)
ROOTLIBS      := $(shell root-config --libs)
ROOTGLIBS     := $(shell root-config --glibs)
ROOTLIBS      := $(shell root-config --nonnew --libs)
CFLAGS        += $(ROOTCFLAGS)
LIBS          += $(ROOTLIBS)
# Not sure why Minuit isn't being included -- put in by hand
#
LIBS          += -lMinuit
LDFLAGS       = -O

$(PROGNAME) :    $(OBJECTS)
                g++ -o $@ $(OBJECTS) $(LDFLAGS) $(LIBS)

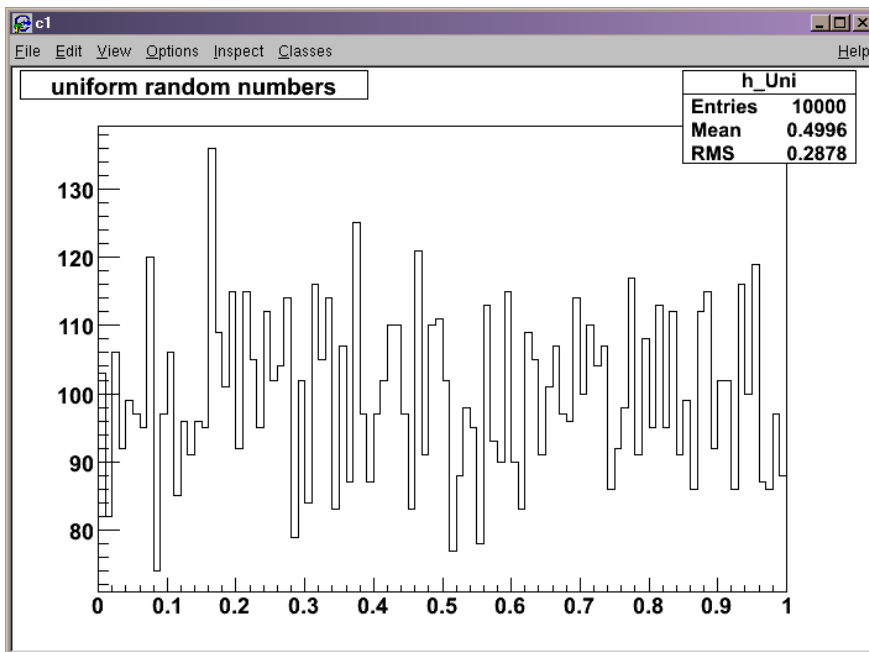
%.o : %.cc $(INCLUDES)
        g++ ${CFLAGS} -c -g -o $@ $<
```

# Looking at output `simpleMC.root`

You type at root prompt  
(lines numbered [0], [1], etc.)

```
[linappserv2]~/l1/ld/stat/root/mc> root
*****
* Welcome to ROOT v5.14/00e *
*****

root [0] TFile* f = new TFile("simpleMC.root");
root [1] f->ls();
TFile**      simpleMC.root
TFile*       simpleMC.root
  KEY: TH1D   h_Uni;1 uniform random numbers
  KEY: TH1D   h_Exp;1 exponential random numbers
root [2] h_Uni->Draw();
<TCanvas::MakeDefCanvas>; created default TCanvas with name c1
root [3] █
```

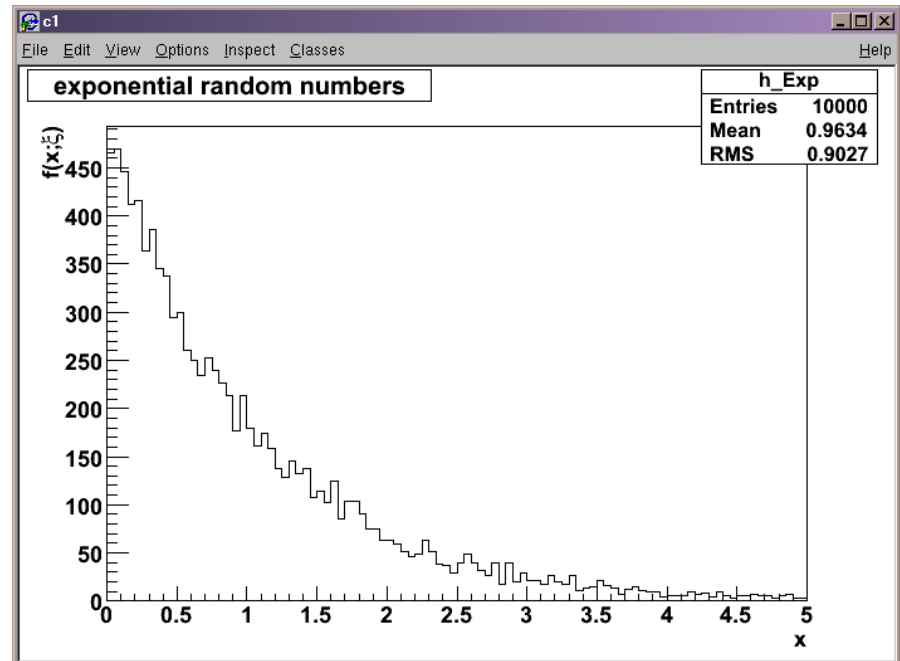


ROOT creates canvas.

To save plot: File, Save as, etc.

# Better plots (store commands in a macro file)

```
// To execute, type .X plotHist.C
{
  TFile* f = new TFile("simpleMC.root");
  f->ls();
  TH1D* h1 = (TH1D*)f->Get("h_Exp");
  h1->SetXTitle("x");
  h1->SetYTitle("f(x;#xi)");
  h1->Draw();
}
```



# Carry on with ROOT

Root home page: `root.cern.ch` (manual, tutorials, etc.)

Class definitions: `root.cern.ch/root/html/ClassIndex.html`

E.g. for TH1D: `root.cern.ch/root/html/TH1D.html`  
(tick box “show inherited”).

More ROOT lectures (links from course website):

Adrian Bevan (QMUL)

`www.ph.qmul.ac.uk/~bevan/GCL/ROOT.pdf`

Benno List (DESY)

`www.desy.de/~blist/summerstudents/  
summer_lectures.2007cpp.html`