ROOT Introduction

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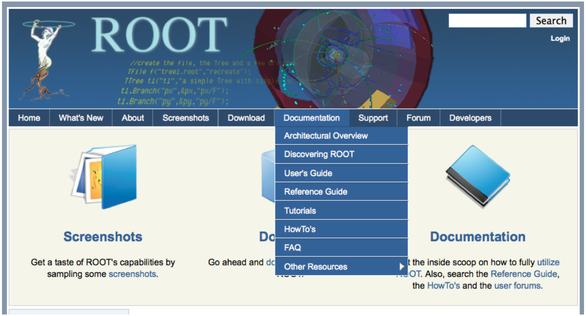
Outline

What is ROOT?

- ROOT is a software for **data analysis** developed by CERN
- Used heavily by experimental particle physicists
- ROOT is based on C++ classes
- Many additional classes
- Useful for
  - data analysis
  - plotting
  - fitting
- ROOT website

ROOT Website



What is useful for you:

- Discovering ROOT: some more informations
- Users Guide: printable version and explanation of the various ROOT classes
- ROOTPrimer: compact ROOT introduction (5̃0 pages)
- Reference Guide: your best friend to find out the available methods of each class
- Tutorials and HowTo's: to use if you need help or inspiration

Starting ROOT

- Installation
  - Windows and Mac: binaries here
  - Ubuntu: apt-get install root-system or debian files
  - Fedora: yum install root
- Start ROOT
  - Open Terminal and type **root** (-l to not show ROOT logo)
  - Using the arrows you can get the previously used code lines
  - To close application type **.q**

My First Macro

- Download and have a look at myfirstMacro.cxx
- Run it with root:
  - start root
  - .x myfirstMacro.cxx
  - close root
  - or all together: root -q myfirstMacro.cxx

```cpp
void myfirstMacro(){

  gROOT->Reset();
  gROOT->SetStyle("Plain");

  std::cout<<"This is my first macro"<<std::endl;

  int num = 2;

  std::cout<<"number defined num="<<num<<std::endl;

  std::cout<<"second power of "<<num<<" is: "<<num*num<<std::endl;
  std::cout<<"second power of "<<num<<" with TMath function is: "<<
TMath::Power(num,2)<<std::endl;

  std::cout<<"Multiplication Table"<<std::endl;

  for (int i=0; i<11; ++i){
    std::cout<<num<<"*"<<i<<"="<<num*i<<std::endl;
  }

}
```

```
hepbook33:ROOTIntro claudia$ root
root [0] .x myfirstMacro.cxx
This is my first macro
number defined num=2
second power of 2 is: 4
second power of 2 with TMath function is: 4
Multiplication Table
2*0=0
2*1=2
2*2=4
2*3=6
2*4=8
2*5=10
2*6=12
2*7=14
2*8=16
2*9=18
2*10=20
root [1] .q
hepbook33:ROOTIntro claudia$
```

Some important classes

- **4-Vectors**: ROOT has the possibility to save the 4-vector of an object
  - TLorentzVector
  - Flexible object to save properties of a particle
- **Graphs**: given a pair (x,y) draw a point
  - ROOT class TGraph
  - ROOT class TGraphErrors
- **Functions**:
  - ROOT class TF1
  - Fit a histogram with a function
- **Histograms**: represent the probability of one event to happen, if you want to visualise it look here
  - ROOT Base class TH1
  - We will use mainly TH1F (1-d histograms with float values) and TH2F (2-d histograms with float values)
- **Trees**: save same information for all events. Easy to manipulate and retrieve saved information.
  - ROOT class TTree

How we proceed

- Try some easy commands interactively
- Try to understand and run some macros
- Then modify them
- Simple macros - thanks F. Bührer
  http://wwwhep.physik.uni-freiburg.de/∼cgiulian/AppliedParticlePhysics/ROOTIntroduction/
- More complex macros taken from ROOT tutorials
- You can find them in $ROOTSYS/tutorials
- You can use them for further exercises

4-Vectors: TLorenzVector

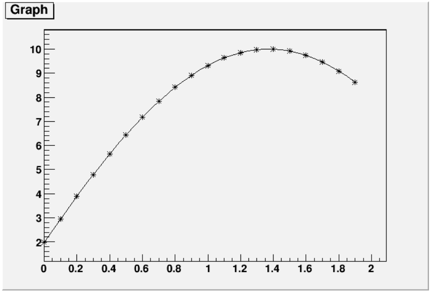
- Particle Physics: we want to study particles
- Save the particle properties in a sensible way
- Particle Energy-Momentum vector is an important quantity
- ROOT gives us an easy and flexible tool: TLorentzVector
- we can set, and later retrieve, the vector components
- e.g. we have a particle with Px=100 GeV, Py=30 GeV, Pz=50 GeV and E=200 GeV

```
TLorentzVector * particle = new TLorentzVector();
particle->SetPxPyPzE(100.,30.,50.,200.);
also possible:  SetPtEtaPhiE(), SetPtEtaPhiM()
[ or also SetXYZT() for a space-time vector ]
particle->Pt() :  to get the transverse momentum
of the particle
particle->M() :  to get the mass
```

TGraph

- Graph: plot a pair (x,y), e.g. x and y coordinates of an object moving on a plane
- ROOT class: TGraph
- TCanvas: canvas where the plots are drawn

```
{
  TCanvas *c1 = new TCanvas("c1","A Simple Graph
Example",200,10,700,500);
  Double_t x[100], y[100];
  Int_t n = 20;
  for (Int_t i=0;i<n;i++) {
    x[i] = i*0.1;
    y[i] = 10*sin(x[i]+0.2);
  }
  gr = new TGraph(n,x,y);
  gr->Draw("AC*");
  return c1;
}
```



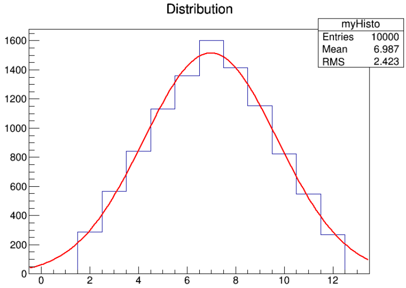
Histograms: TH1

- Download dices.cxx
- Open the macro and try to understand what is done
- Run it with: root dices.cxx

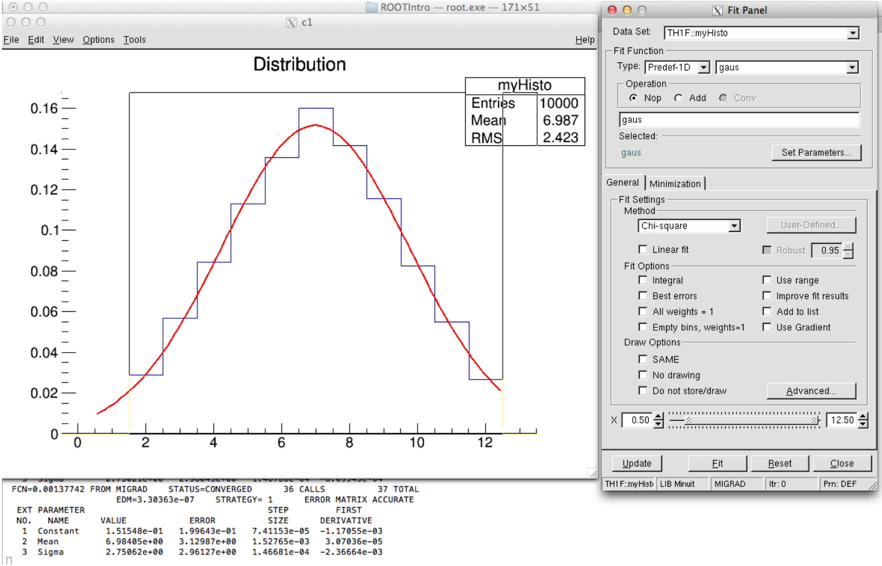
dices.cxx

```
void dices(){
  TRandom3 *rnd = new TRandom3(); // random number generator
  TH1F* myHist=new TH1F("myHisto","Distribution",14,-0.5,13.5); //histogram definition: 14 bins from -0.5 to 13.5
  TCanvas *c1=new TCanvas("c1","c1",800,600); //canvas definition
  for(int i=0; i<10000; i++){
    int dice1=(int)(rnd->Rndm()*6)+1; //Rndm generates random numbers between 0 and 1
    int dice2=(int)(rnd->Rndm()*6)+1;

    myHist->Fill(dice1+dice2);
    if(i<10){
      cout <<dice1<<" + "<<dice2<<" = "<<dice1+dice2<<endl;
      myHist->Draw();
      TString title="hist_"; //string ROOT type
      title+=i; title+=".png";
      c1->SaveAs(title);
    }

  }
  myHist->Draw();
  c1->SaveAs("hist_10000.png"); //equivalently ->Print()
  myHist->Scale(1./myHist->GetEntries());
  c1->SaveAs("hist_10000scaled.png");
}
```

-U:--- dices.cxx All L9 (C++/l Abbrev)----



Fit a Histogram with GUI



Files and Trees: TFile and TTree

- Download Top.root
- To open the file: root Top.root
- To visualise the content of the file: TBrowser b