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ROOT and RooFit

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2024年8月1日

Outline

- ROOT 介绍
- 一些例子
- RooFit 介绍
- 一些例子
- 总结

ROOT 介绍

ROOT
Data Analysis Framework

About | Learn | Install | Forum & Help | Manual | Blog Posts | Contribute | For Developers

ROOT的主页，由CERN维护。

ROOT: analyzing petabytes of data, scientifically.

An open-source data analysis framework used by high energy physics and others.

Learn more | Install v6.32.02

基于面向对象设计的数据分析软件框架！

Learn | Reference | Forum | Gallery

√-1

ROOT enables *statistically sound* scientific analyses and visualization of large amounts of data: today, more than 1 exabyte (1,000,000,000 gigabyte) are stored in ROOT files. The Higgs was found with ROOT!

As *high-performance* software, ROOT is written mainly in C++. You can use it on Linux, macOS, or Windows; it works out of the box. ROOT is open source: use it freely, modify it, contribute to it!

$ _

ROOT comes with an incredible C++ interpreter, ideal for *fast prototyping*. Don't like C++? ROOT integrates super-smoothly with Python thanks to its unique dynamic and powerful Python ⇄ C++ binding. Or what about using ROOT in a Jupyter notebook?

ROOT 介绍

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- Framework for large scale data handling
- Provides, among others,
  - an efficient data storage, access and query system (PetaBytes)
  - advanced statistical analysis: histogramming, fitting, minimization and multi-variate analysis algorithms
  - scientific visualization: 2D and 3D graphics, Postscript, PDF, LateX
  - geometrical modeler
  - PROOF parallel query engine
- An Open Source Project
- User Interface
  - GUI: Browsers, Panels, Tree Viewer
  - Command Line interface: C++ interpreter CINT
  - Script Processor (C++ compiled   C++ interpreted)

ROOT 介绍

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- Start:

$ root Start the ROOT
$ root –l Does not show the ROOT banner
root [0] .q quit the ROOT
root [1] .x <file_name> .x name.cxx (execute)
root [2] .L <file_name> .L name.cxx (load)

$ root –l name.root open file
root [0] .ls look list
root [1] treename->Print() list all branches in this tree
root [2] treename->Draw("branch") draw branch
root [3] treename->Scan() print message

- Calculator root

[0] 1+1
root [1] 2*(50+91)/12.
root [2] sqrt(3.)
root [3] TMath::Pi()

> root -h
Usage: root [-l] [-b] [-n] [-q] [file1.C ... fileN.C] Options:
-b : run in batch mode without graphics
以批处理形式运行不显示图， 远程操作需要，减少等待时间和流量。
-n : do not execute logon and logoff macros as specified in .rootrc
-q : exit after processing command line script files
运行完脚本文件后自动退出，非常有用，在脚本中运行root需要。
-l : do not show the image logo (splash screen)

```
*******************************************
*                                         *
*        W E L C O M E  to  R O O T       *
*                                         *
*   Version   5.34/09      26 June 2013   *
*                                         *
*  You are welcome to visit our Web site  *
*          http://root.cern.ch            *
*                                         *
*******************************************

ROOT 5.34/09 (v5-34-09@v5-34-09, Jun 26 2013, 17:10:36 on linuxx8664gcc)

CINT/ROOT C/C++ Interpreter version 5.18.00, July 2, 2010
Type ? for help. Commands must be C++ statements.
Enclose multiple statements between { }.
```

Creating ROOT macros

The name of the ROOT macro and the file name (without file extension) in which the macro is saved must match.

1. Create a new file in your preferred text editor.
2. Use the following general structure for the ROOT macro, preferably with a function that has the same name as the file:

```c++
void MacroName() {
   ...

   your lines of C++ code
   code line ends with ;
   ...
}
```

1. Save the file ROOT macro, using the macro name as file name: **MacroName**.C

Note

It's not necessary to `#include` anything in the ROOT macros. Everything in the include paths is automatically included. Note that you can type `.I` in the ROOT prompt to see the include paths, and `.I [path]` to add an extra path.

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- $ROOTSYS/tutorials: contains many example scripts. They assume some basic knowledge of C++ and ROOT

  copy them to your home directory and try!

- Some Reference： *https://root.cern/learn/*
  - The ROOT beginners' guide (aka "Primer")
  - The Manual where more in depth information can be found
  - The full API Documentation
  - The Tutorials

- You can find sample program of next two paths:

  /scratchfs/bes/wwangbo/draw/draw/ (ihepc)

  /ustcfs/BES3User/2021/bwang/draw/ (ustc)

  draw1.cxx and draw2.cxx are used to draw figures opetree.cxx is used to modify tree in the root file

draw1.cxx

读文件 建立直方图

```
void draw1(){

        gStyle->SetOptStat(0);
        //information in statistics via parameter mode

        TFile *File = new TFile("../rhopi3097_001.root");
        //read file
        TTree *Tree = (TTree*)File->Get("fit5c");
        //read tree in the file
        TFile *File1 = new TFile("../rhopi3097_002.root");
        TTree *Tree1 = (TTree*)File1->Get("fit5c");
        TFile *File2 = new TFile("../rhopi3097_003.root");
        TTree *Tree2 = (TTree*)File2->Get("fit5c");
        TFile *File3 = new TFile("../rhopi3097_004.root");
        TTree *Tree3 = (TTree*)File3->Get("fit5c");

        TCut cut = "";
        //selection
        //cut1+cut2=(cut1)&&(cut2)      cut1||cut2=(cut1)||(cut2)

        double bin(100), lo(0), up(3);
        //bins and the range
        TString val = "mrh0";
        //name of variable

        TH1F *h = new TH1F("h", "", bin, lo, up);
        //H for histogram, F for float
        TH1F *H[5];
        //Hist in array form
        for(int i=0; i<5 ;i++)
        {
```

输入需要绘图的root文件

输入root中待分析的tree

创建一个新的直方图，bin指的是区间数, lo, up指的是上下限

draw1.cxx

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建立画布 将变量加进直方图

```
TH1F *H[5];
//Hist in array form
for(int i=0; i<5 ;i++)
{
H[i] = new TH1F(Form("H%d", i), "", bin, lo, up);
}

TCanvas *c = new TCanvas("c","c",10,10,800,600);
//define a canvas
Tree->Draw(val+">>h",cut);
//consider as signal
Tree1->Draw(val+">>H0",cut);
Tree2->Draw(val+">>H1",cut);
Tree3->Draw(val+">>H2",cut);
//consider as data

h->SetYTitle("Events");
h->SetXTitle("M_{#rho^{0}}");
h->GetYaxis()->SetLabelSize(0.043);
//size of label of Yaxis
h->GetYaxis()->SetRangeUser(0,10000);
//range of Yaxis

h->SetLineWidth(3);                    //TAttLine Class
h->SetLineColor(kRed);
h->Scale(2);                   //scale

H[2]->SetMarkerSize(0.9);                      //TAttMarker Class
H[2]->SetMarkerStyle(8);
H[2]->SetLineWidth(2);
H[2]->Scale(2*h->GetEntries()/H[2]->GetEntries());
```

将Tree中的 mrho画在画布上

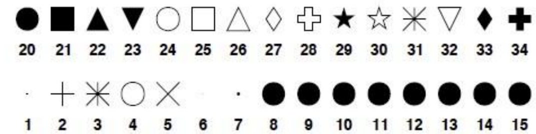
设置图像的具体细节，比如线的粗细，点的大小，坐标轴名称之类的

draw1.cxx

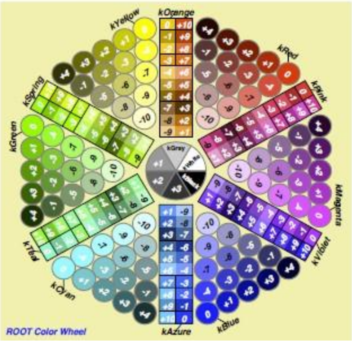
设置堆积图 一般用来描述本底

```
THStack *hs = new THStack("hs","");
H[0]->SetLineColor(kOrange);
H[0]->SetLineWidth(2);
H[0]->SetFillColor(kOrange);
H[0]->SetFillStyle(3344);
H[1]->SetLineColor(kBlue);
H[1]->SetLineWidth(2);
H[1]->SetFillColor(kBlue);
H[1]->SetFillStyle(3344);
hs->Add(H[0]);
//add hist
hs->Add(H[1]);
```

- Available markers in ROOT



- Available Colors



you can access them from the Canvas View Menu

画出直方图

```
h->Draw("hist");
hs->Draw("same");
H[2]->Draw("same hist ep");
//e for error, p for point
```

Graphs can be drawn with the following options:

Option	Description
"A"	Axis are drawn around the graph
"L"	A simple polyline is drawn
"F"	A fill area is drawn ('CF' draw a smoothed fill area)
"C"	A smooth Curve is drawn
"*"	A Star is plotted at each point
"P"	The current marker is plotted at each point
"B"	A Bar chart is drawn
"1"	When a graph is drawn as a bar chart, this option makes the bars start from the bottom of the pad. By default they start at 0.
"X+"	The X-axis is drawn on the top side of the plot.
"Y+"	The Y-axis is drawn on the right side of the plot.

draw1.cxx

设置图例

```
TLegend *leg = new TLegend(0.6, 0.7, 0.85, 0.85);
//legend
leg->SetFillColor(0);
leg->SetNColumns(2);
//2 columns
leg->SetBorderSize(0);
leg->AddEntry(h,"signal","l");
//l for line, f for fill, e for error, p for point
leg->AddEntry(H[2],"data","ep");
leg->AddEntry(H[0],"back1","f");
leg->AddEntry(H[1],"back2","f");
leg->Draw();
```

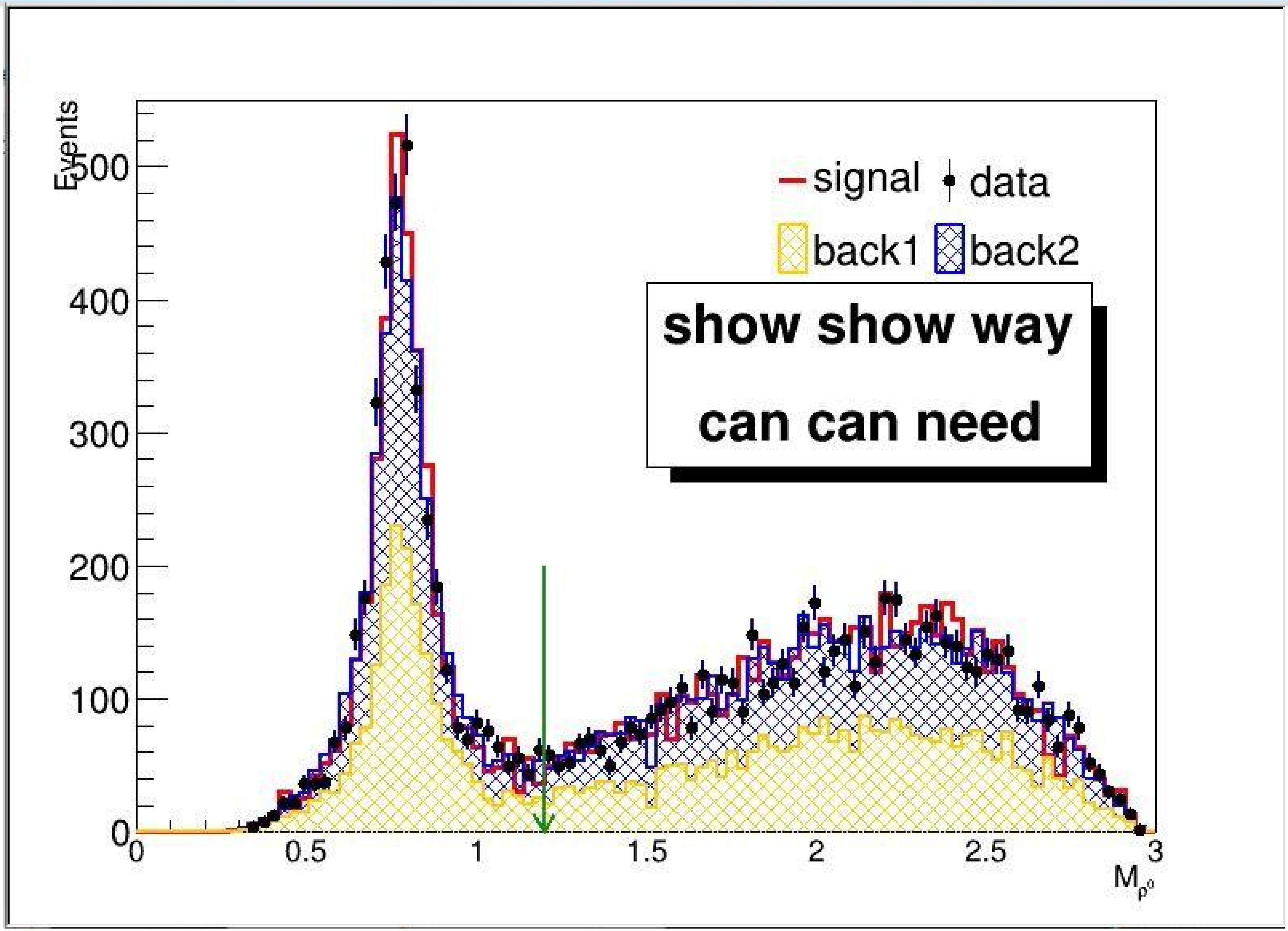
设置箭头

```
TArrow *arrow = new TArrow(1.2,200,1.2,0,0.02,">");
//TArrow Class
arrow->SetFillColor(1);
arrow->SetFillStyle(1001);
arrow->SetLineColor(kGreen+2);
arrow->SetLineWidth(2);
arrow->Draw();
```

设置文本框

```
TPaveText *pt = new TPaveText(0.5,0.5,0.85,0.7,"BRNDC");
pt->SetFillColor(10);
pt->SetBorderSize(10);
pt->SetTextAlign(22);
TString par1 = "show show way";
TString par2 = "can can need";
```

draw1.cxx


Events
500
400
300
200
100
0
0
0.5
1
1.5
2
2.5
3
M_{ρ^0}
signal
data
back1
back2
show show way
can can need

draw2.cxx

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另一种读取root的方式

```
TChain *chain = new TChain("fit5c");
chain->Add("../rhopi3097_001.root");
chain->Add("../rhopi3097_005.root");
```

这样可以一次性读取多个root文件

```
double m1,m2,m3,m4,chisq;
chain->SetBranchAddress("mrh0",&m1);
chain->SetBranchAddress("chi2",&chisq);
Tree1->SetBranchAddress("mrh0",&m2);
Tree2->SetBranchAddress("mrh0",&m3);
Tree3->SetBranchAddress("mrh0",&m4);

for(int i=0; i<chain->GetEntries(); i++){
        chain->GetEntry(i);
        /*if(chisq<50)*/ sig->Fill(m1);
}
for(int i=0; i<Tree1->GetEntries(); i++){
        Tree1->GetEntry(i);
        data->Fill(m2);
}
for(int i=0; i<Tree2->GetEntries(); i++){
        Tree2->GetEntry(i);
        back1->Fill(m3);
}
for(int i=0; i<Tree3->GetEntries(); i++){
        Tree3->GetEntry(i);
        back2->Fill(m4);
```

另一种将变量填入直方图的方式，这里的data, back1, 2啥的都是前面的定义过的直方图

draw2.cxx

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将画布分为两部分，打开第一部分（内容与draw1.cxx类似）

```
TCanvas *c = new TCanvas("c","c",10,10,1200,500);
c->Divide(2,1);
c->cd(1);
```

```
c->cd(2);
double x[10], y[10];
for(int i=0; i<10; i++){
        x[i] = i+1;
        y[i] = sin(x[i])/x[i]+0.1;
}
TGraph *gr = new TGraph(10,x,y);

gr->SetLineWidth(3);
gr->SetLineColor(2);
gr->SetMarkerStyle(4);
gr->SetMarkerColor(3);

gr->GetYaxis()->SetRangeUser(-0.3,1.2);

gr->Draw("ACP");
```

打开第二部分，使用已知数组画图，这里等于画了一个函数的散点图。

draw2.cxx

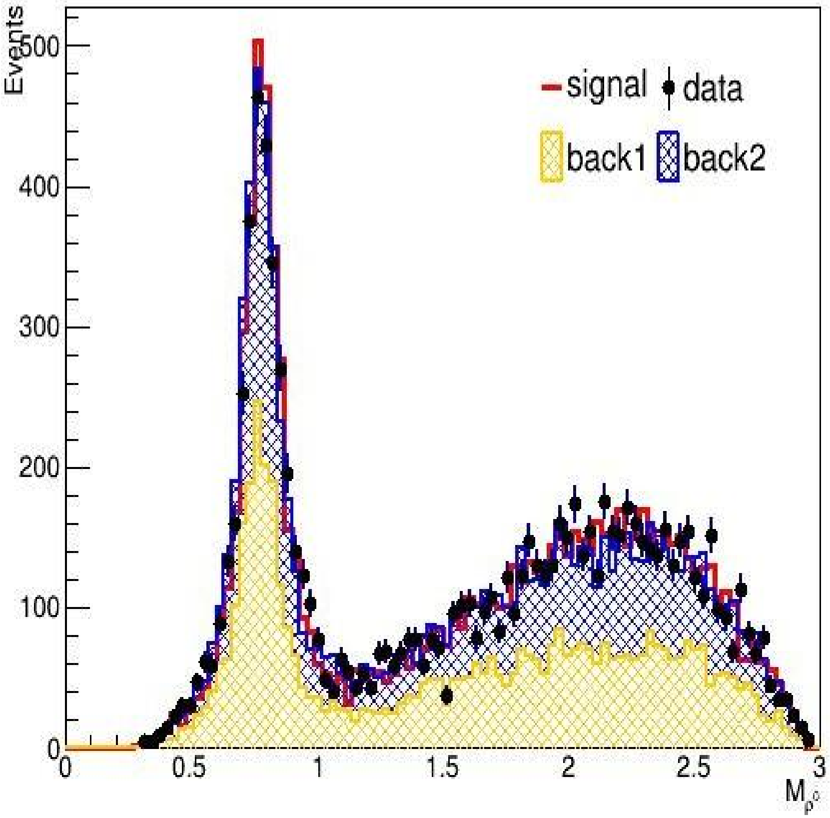
使用公式画图与超简单拟合

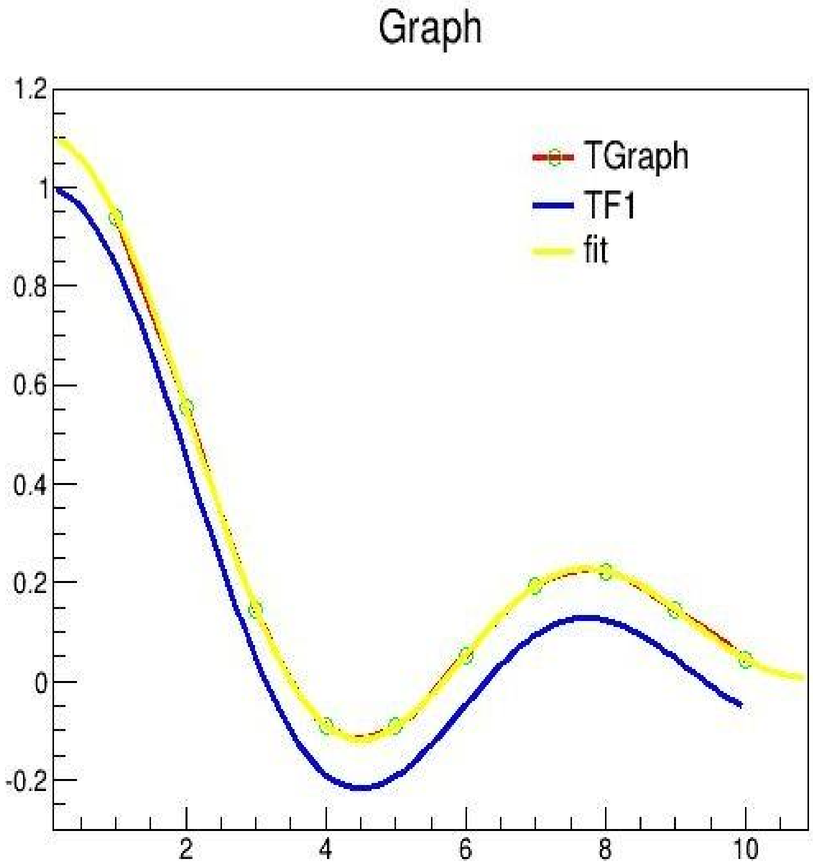
```
TF1 *f = new TF1("fun", "sin(x)/x", 0, 10);
f->SetLineWidth(3);
f->SetLineColor(4);
f->Draw("same");

TF1 *f_fit = new TF1("f_fit", "sin(x)/x+[0]",0,10);
f_fit->SetLineWidth(3);
f_fit->SetLineColor(5);
f_fit->SetParameter(0,1);
gr->Fit("f_fit");
f_fit->Draw("same");
```

新定义一个函数绘制其连续图像

对刚刚绘制的函数散点图进行拟合

draw2.cxx


Events
signal
data
back1
back2
0
100
200
300
400
500
0
0.5
1
1.5
2
2.5
3
M_{ρ^0}


Graph
TGraph
TF1
fit
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
2
4
6
8
10

opeTree.cxx

读取文件和tree

```
TFile *infile = new TFile("../rhopi3097_010.root");
TTree *intree1 = (TTree*)infile->Get("vxyz");
TTree *intree2 = (TTree*)infile->Get("photon");
TTree *intree3 = (TTree*)infile->Get("dedx");
TTree *intree4 = (TTree*)infile->Get("tof1");
TTree *intree5 = (TTree*)infile->Get("tof2");
TTree *intree6 = (TTree*)infile->Get("pid");
TTree *intree7 = (TTree*)infile->Get("etot");
TTree *intree8 = (TTree*)infile->Get("fit4c");
TTree *intree9 = (TTree*)infile->Get("fit5c");
TTree *intree10 = (TTree*)infile->Get("geff");
TTree *intree11 = (TTree*)infile->Get("tofe");
```

opeTree.cxx

综合性操作 加减branch 添加cut条件

```
//fit5c
double chisq, mrh0_1, mrhp_1, mrhm_1;
intree9->SetBranchAddress("mrh0",&mrh0_1);
//read branch
intree9->SetBranchAddress("mrhp",&mrhp_1);
intree9->SetBranchAddress("chi2",&chisq);
intree9->SetBranchStatus("mrhm",0);
//0 means deactive;  don't clone this branch while cloning in tree intree9

TFile *newfile = new TFile("../test.root", "recreate");
TTree *newfit5c = intree9->CloneTree(0);
//clone without value in the branch

double sum;
TBranch *Br1 = newfit5c->Branch("sum",&sum);
//built a new branch of tree newfit5c

for(int i=0; i<intree9->GetEntries(); i++)
{
        intree9->GetEntry(i);
        sum = mrh0_1+mrhp_1;                    //define the new variable
        if(chisq<50) newfit5c->Fill();                  //add cut
}
newfit5c->Print();
//newfit5c->Write();
```

opeTree.cxx

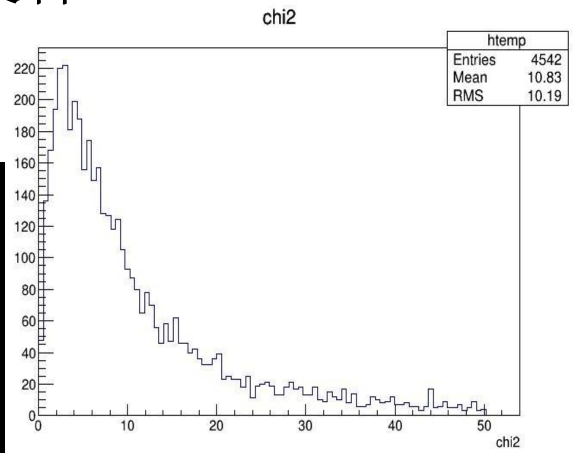
```
//Copy tree
intree1->SetBranchStatus("*", 0);
//all deactive
intree1->SetBranchStatus("vx0", 1);
//1 mean active

TTree *newtree1 = intree1->CloneTree();
//clone all without fill
newtree1->Print();
//newtree1->Write();


//Cut tree
TTree *newfit4c = intree8->CopyTree("chi2<50");
newfit4c->Print();
//newfit4c->Write();


newfile->Write();
//write the file
//delete newfile;
```

复制tree

添加cut条件

写入新文件

```
[wangyijing@lxslc705 ~/draw]$ root -l test.root
^[[Aroot [0]
Attaching file test.root as _file0...
root [1] .ls
TFile**         test.root
 TFile*         test.root
  KEY: TTree    fit5c;1 ks N-Tuple example
  KEY: TTree    vxyz;1  ks N-Tuple example
  KEY: TTree    fit4c;1 ks N-Tuple example
root [2]
```



拟合初介绍

- 什么是拟合
  - ✓我们的数据一般是一些离散的点，我们用比如极大似然值法，得到一个最好的参数化公式去描述数据。
- 为什么拟合
  - ✓我们得到的参数化公式往往可能蕴含某种物理规律。比如粒子物理最常见的去拟合不变质量谱得到一个BW函数，就是研究一个我们感兴趣的共振态的最直接有效的方法。

Fit Methods：

Maximum Likelihood (ML) Fit

χ^2 **Fit**

RooFit 介绍

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What is it?

- A powerful toolkit for modeling the expected distribution(s) of events in a physics analysis
- Primarily targeted to high-energy physicists using ROOT
- Originally developed for the BaBar collaboration by Wouter Verkerke and David Kirkby.
- Included with ROOT v5.xx

Documentation:

- http://root.cern.ch/root/Reference.html – for latest class descriptions. RooFit classes start with "Roo".
- http://roofit.sourceforge.net – for documentation and tutorials

Tutorials:

- Dig $ROOTSYS/tutorials/rootfit

Basic Classes

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- Mathematical objects are represented as C++ objects

Mathematical concept		RooFit class
variable	x	`RooRealVar`
function	$f(x)$	`RooAbsReal`
PDF	$f(x)$	`RooAbsPdf`
space point	$\vec{x}$	`RooArgSet`
integral	$\int_{x_{min}}^{x_{max}} f(x)dx$	`RooRealIntegral`
list of space points		`RooAbsData`

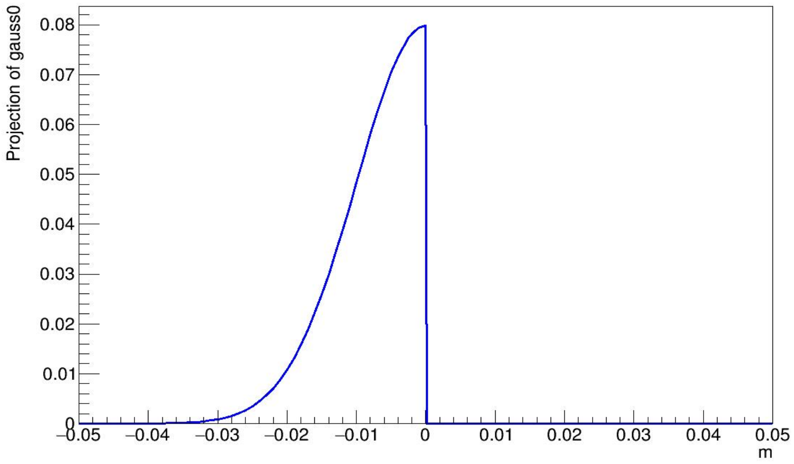
常用的PDF类型

- RooGaussian
- RooExponential
- RooPolynomial
- RooChebychev
- RooBreigWigner
- RooArgusBG
- RooBiFurGauss
- RooCrystalBall

- Gaussian
- Exponential
- Polynomial
- Chebychev polynomial
- Breit-wigner
- Argus
- Bifurcated Gaussian
- Crystal Ball

这些都算作前面提到的RooAbsPdf！！

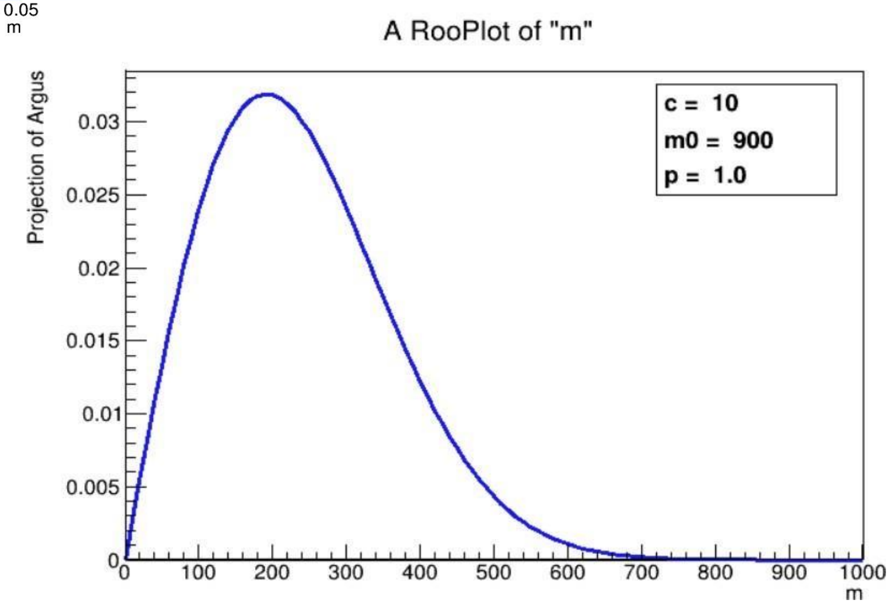
常用的PDF类型



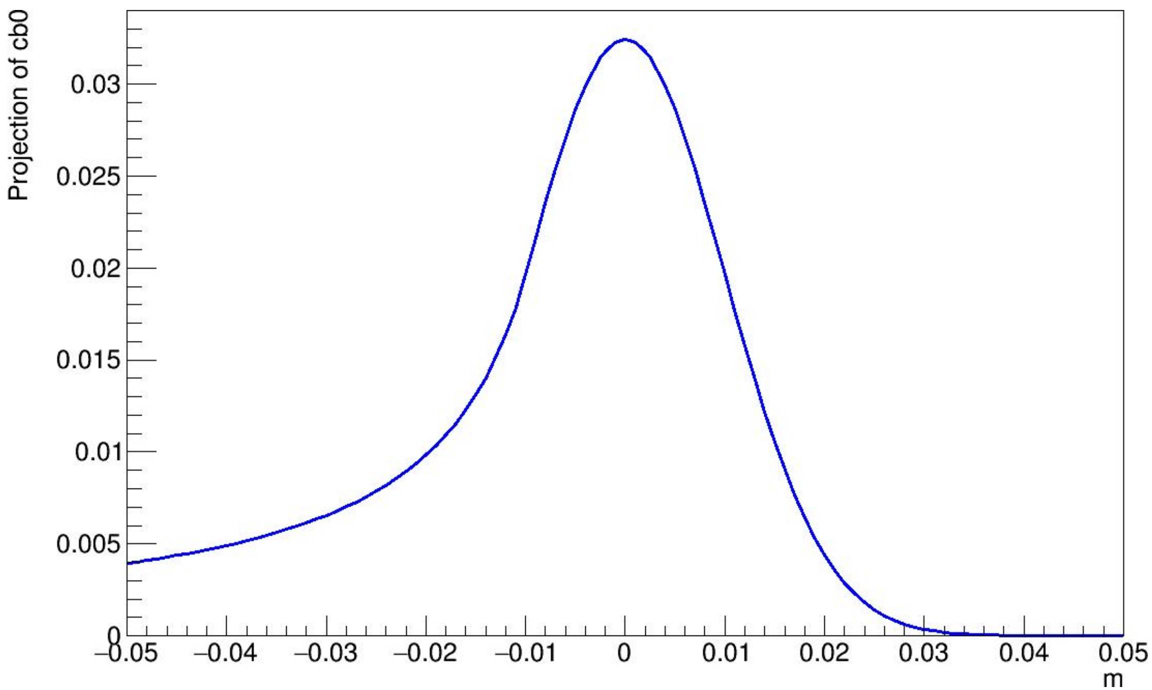
Bifurcated Gaussian

Argus

$$\mathrm{Argus}(m, m_0, c, p) = \mathcal{N} \cdot m \cdot \left[1 - \left(\frac{m}{m_0}\right)^2\right]^p \cdot \exp\left[c \cdot \left(1 - \left(\frac{m}{m_0}\right)^2\right)\right]$$



常用的PDF类型



Crystal Ball

$$f(m; m_0, \sigma, \alpha_L, n_L, \alpha_R, n_R) = \begin{cases} A_L \cdot (B_L - \frac{m-m0}{\sigma L})^{-n_L}, & \text{for } \frac{m-m0}{\sigma L} < -\alpha_L \\ \exp\left(-\frac{1}{2} \cdot \left[\frac{m-m0}{\sigma L}\right]^2\right), & \text{for } \frac{m-m0}{\sigma L} \leq 0 \\ \exp\left(-\frac{1}{2} \cdot \left[\frac{m-m0}{\sigma R}\right]^2\right), & \text{for } \frac{m-m0}{\sigma R} \leq \alpha_R \\ A_R \cdot (B_R + \frac{m-m0}{\sigma R})^{-n_R}, & \text{otherwise,} \end{cases}$$

$$A_i = \left(\frac{n_i}{|\alpha_i|}\right)^{n_i} \cdot \exp\left(-\frac{|\alpha_i|^2}{2}\right)$$

$$B_i = \frac{n_i}{|\alpha_i|} - |\alpha_i|$$

基本的操作

- 最终我们要进行的操作是：把一个用参数(RooRealVar)描述的**PDF(RooAbsPdf)**(比如一个用mean值和sigma值描述的gaussian分布)，去拟合到一个数据集**(RooDataSet)**上面，让程序去根据自己的算法，找到这些参数最好的值，来让这个PDF**最精确**地表述这个数据集。

Estimator !!!

- A perfect estimator is （一致性，无偏性，有效性）
  - Consistent: $\lim_{n\to\infty}(\hat{a}) = a$
  - Unbiased – *With finite statistics you get the right answer on average*
  - Efficient $V(\hat{a}) = \left\langle (\hat{a} - \langle \hat{a} \rangle)^2 \right\rangle$ ← This is called the 最小方差界 **Minimum Variance Bound**

No perfect estimators !!

复制一下先！

- 先进到自己的主目录下随便创个文件夹，进去之后cp:
- cp –r /besfs5/groups/jpsi/jpsigroup/user/qinlongyu/shareble/roofit ./
- cd roofit
- source ROOT6_24.csh
  - ✓ 对于某些复杂的拟合，root版本的差别对拟合结果会有挺大的影响(建议用root6)
- vi gauss1.cxx

一个简单的例子

- vi gauss1.cxx

```
void gauss1()
{
  //define my viriable
  RooRealVar x("x","x",-10,10) ;

  //define a gaussian distribution
  RooRealVar mean("mean","mean of gaussian",1,-10,10) ;
  RooRealVar sigma("sigma","width of gaussian",1,0.1,10) ;
  RooGaussian gauss("gauss","gaussian PDF",x,mean,sigma) ;

  // Generate a dataset of 1000 events in x from gauss
  RooDataSet* data = gauss.generate(x,10000) ;

  //define another gaussian distribution
  RooRealVar mean1("mean1","mean1 of gaussian",2,-10,10) ;
  RooRealVar sigma1("sigma1","width1 of gaussian",2,0.1,10) ;
  RooGaussian gauss1("gauss1","gaussian PDF1",x,mean1,sigma1) ;





  // Draw all frames on a canvas
  RooPlot* xframe = x.frame() ;
  RooPlot* xframe2 = x.frame() ;
  TCanvas* c = new TCanvas("c","c",800,400) ;

  c->Divide(2) ;
  c->cd(1) ;
  data->plotOn(xframe) ;
  gauss1.plotOn(xframe) ;
  xframe->Draw() ;

  c->cd(2) ;
  //this line means fit pdf to dataset
  gauss1.fitTo(*data) ;
  data->plotOn(xframe2) ;
  gauss1.plotOn(xframe2) ;
  xframe2->Draw() ;

}
```

先定义一个高斯pdf（gauss)

用这个高斯pdf产生了一个dataset

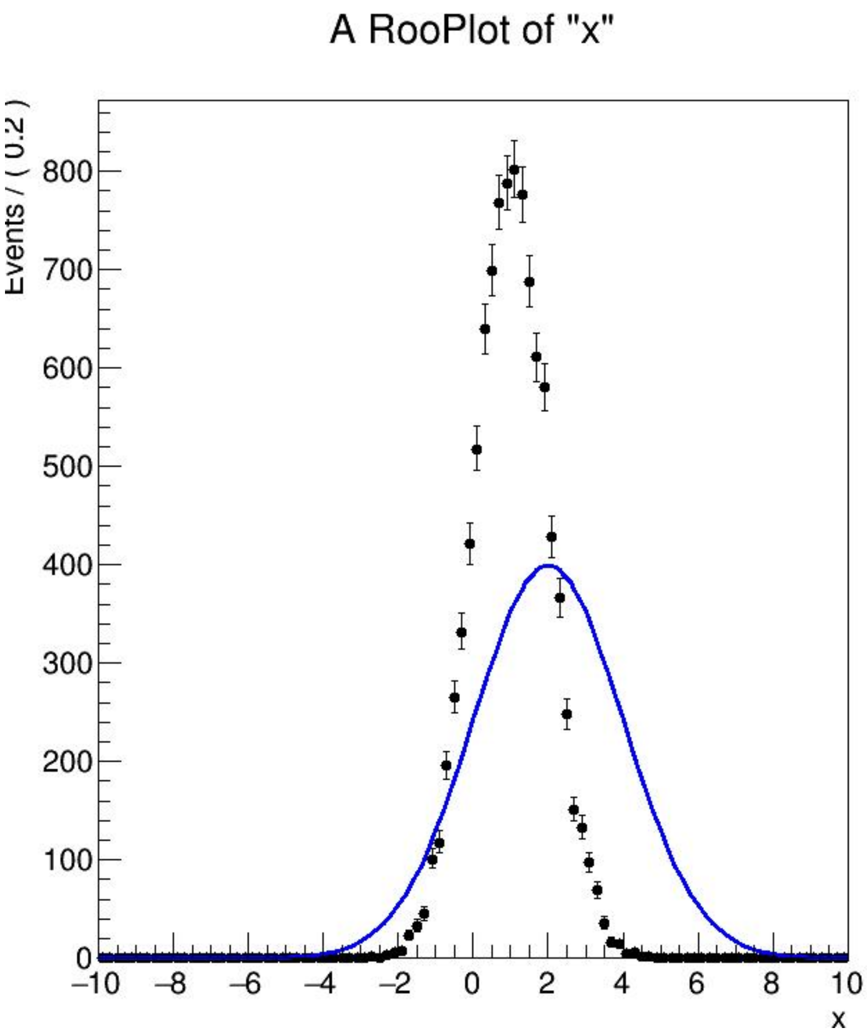
定义参数不一样的高斯pdf（gauss1)

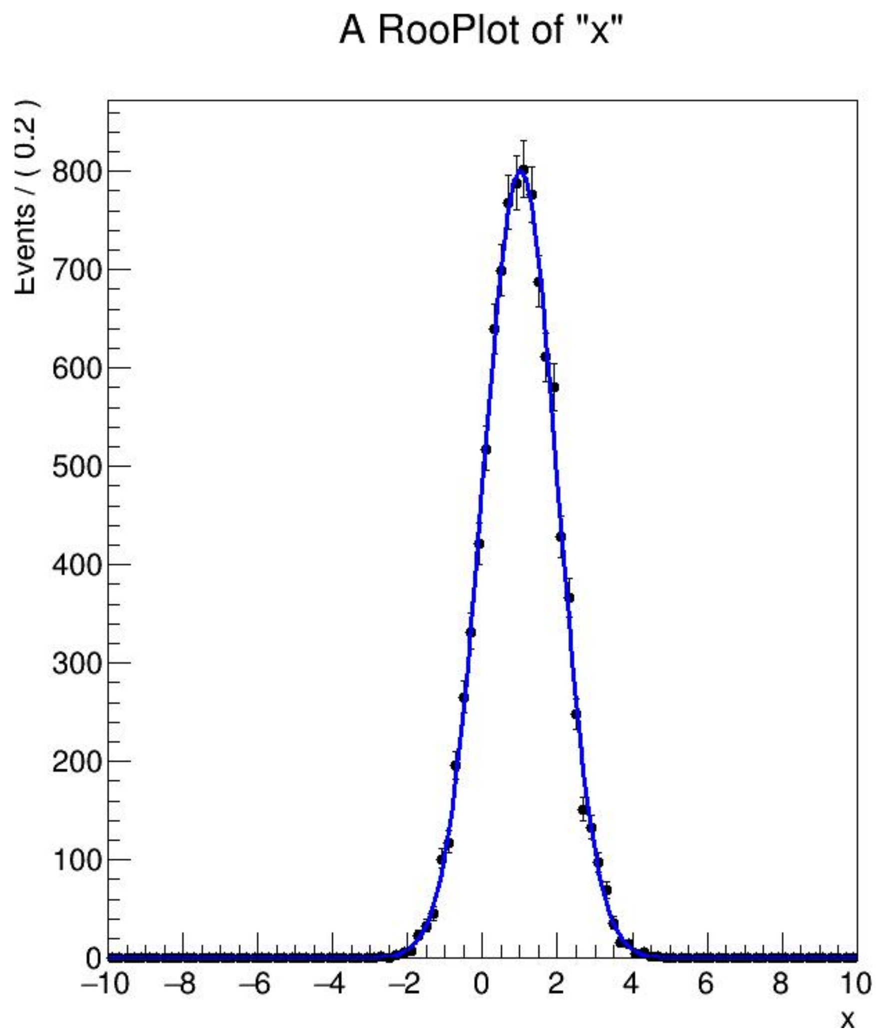
定义两个plot (类似于TH1F) 和一个画布

在左边的画布上画出前面产生的dataset, 以及初始条件下的guass1

在右边的画布上画出前面产生的dataset, 以及拟合后的guass1

运行结果


A RooPlot of "x"
Events / (0.2)
0
100
200
300
400
500
600
700
800
−10
−8
−6
−4
−2
0
2
4
6
8
10
x


A RooPlot of "x"
Events / (0.2)
0
100
200
300
400
500
600
700
800
−10
−8
−6
−4
−2
0
2
4
6
8
10
x

运行结果

Estimate Distance to Minimum，越小越好

OK表示拟合成功

卡方最小值

拟合结果

相关系数

```
**********
**   18 **HESSE        1000
**********
COVARIANCE MATRIX CALCULATED SUCCESSFULLY
FCN=14162.8 FROM HESSE     STATUS=OK            10 CALLS            66 TOTAL
                     EDM=3.21094e-07    STRATEGY= 1      ERROR MATRIX ACCURATE
 EXT PARAMETER                                INTERNAL      INTERNAL
 NO.   NAME       VALUE           ERROR       STEP SIZE       VALUE
  1  mean1         1.00665e+00   9.97346e-03   1.64750e-05   1.00836e-01
  2  sigma1        9.97346e-01   7.05227e-03   8.15530e-06  -9.59175e-01
                               ERR DEF= 0.5
EXTERNAL ERROR MATRIX.    NDIM=  25    NPAR=  2    ERR DEF=0.5
 9.947e-05  8.427e-09
 8.427e-09  4.973e-05
PARAMETER  CORRELATION COEFFICIENTS
      NO.  GLOBAL      1      2
       1  0.00012   1.000  0.000
       2  0.00012   0.000  1.000
```

进阶操作

- 在实际工作当中，我们的dataset一般是会从root文件里面引入
- 而且dataset的构成会比较复杂，一般不会是一个高斯分布就能很轻易描述
- 需要各种pdf按不同的权重求和(RooAddPdf)，构成新的pdf以描述更复杂的dataset.

复杂一些的例子1.0

- vi omegabw.cxx

```
using namespace RooFit;
void omegabwfit()
{

  //here import my data
  TFile *f_data = new TFile("sample.root");
  TTree *t_data = (TTree*)f_data->Get("GammaOmegaPhi");
  //////////////////////////////////////////////////
  RooRealVar momega("momega","M_{#pi^{+}#pi^{-}#pi^{0}} (GeV/c^{2})",0.582,0.982);
  RooDataSet data("data","data",t_data,momega);
  ////////////////////bw conv gaus//////////
  RooRealVar mean0("mean0","mean0",0,-0.1,0.1);
  RooRealVar sigma0("sigma0","sigma0",0.1,0,0.1);
  RooGaussian gausss0("gauss0","gauss0",momega,mean0,sigma0);
  RooRealVar m0("m0","m0",0.782,0.582,0.982);
  m0.setConstant();
  RooRealVar g0("g0","g0",0.00868,0.0,0.020);
  g0.setConstant();
  RooBreitWigner bw0("bw0","bw0",momega,m0,g0);
  RooFFTConvPdf conv1("conv1", "conv1", momega, bw0, gausss0);
  ////////////////////poly////////////////////
  RooRealVar p0("p0", "", 1.3,-2,2);
  RooRealVar p1("p1", "", 0.6,-2,2);
  RooRealVar p2("p2", "", 0.2,-2,2);
  RooChebychev bkgo0("bkgo0", "bkgo0", momega, RooArgList(p0,p1,p2));
  ///////////////////////////////
  RooRealVar nsig("nsig","nsig",19000,0,50000);
  RooRealVar nbkg("nbkg","nbkg",13000,0,50000);

  RooAddPdf summomega("sumomega", "sumomega", RooArgList(conv1,bkgo0), RooArgList(nsig,nbkg));
  summomega.fitTo(data);



  RooPlot* momegaframe = momega.frame();
  TCanvas *c1 = new TCanvas("c1","a canvas",0,0,800,600);
  ////////////////////
  c1 -> cd();
  data.plotOn(momegaframe);
  summomega.plotOn(momegaframe,LineColor(4));
  summomega.plotOn(momegaframe,Components(conv1),LineStyle(4),LineColor(2), LineWidth(3));
  summomega.plotOn(momegaframe,Components(bkgo0),LineStyle(2),LineColor(7), LineWidth(3));
  momegaframe -> Draw();
}
```

→ 读取ROOT文件

→ 定义gauss0，bw0

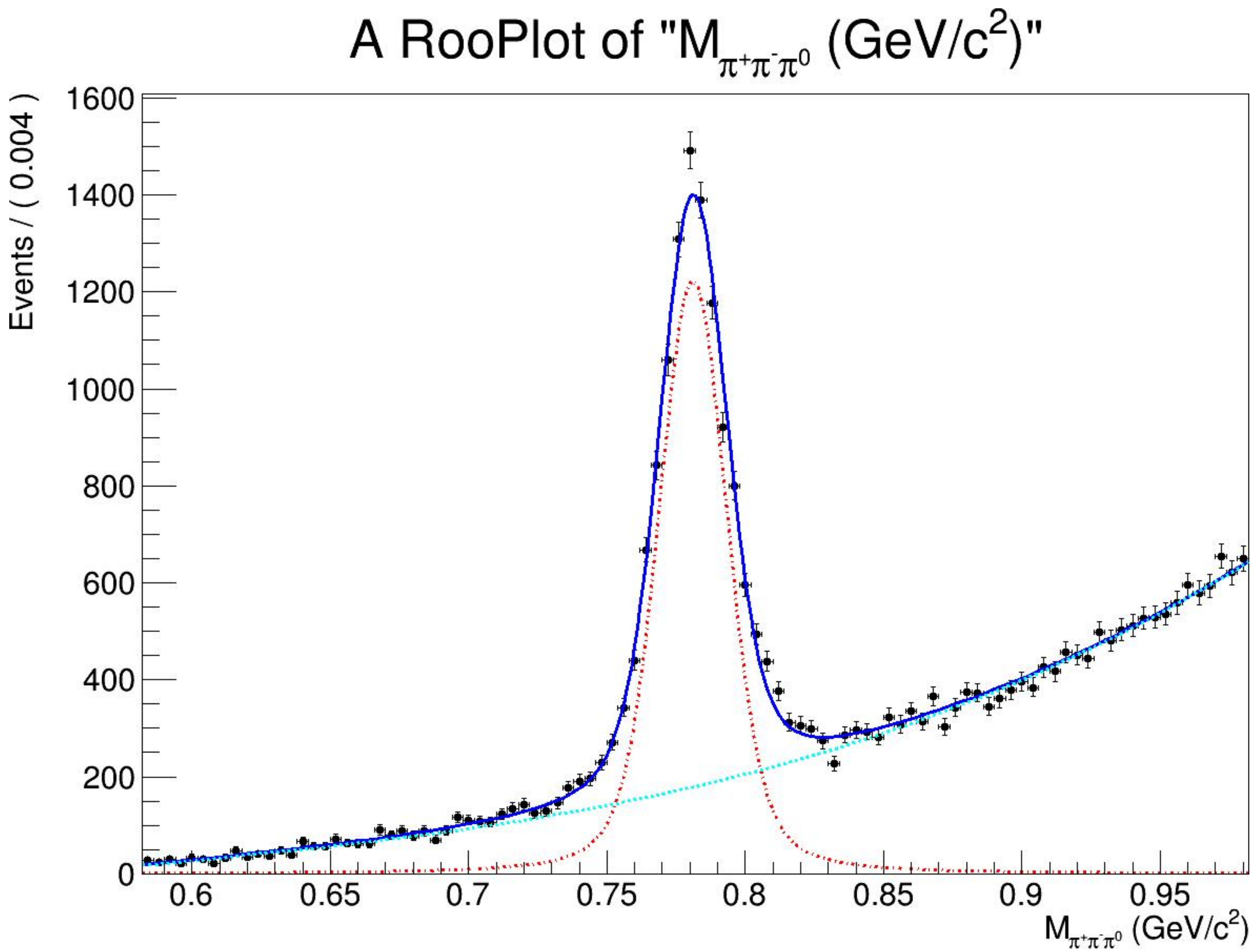
→ 卷积gauss0、bw0为conv1（描述信号）

→ 定义切比雪夫多项式（描述本底）

→ 将 conv1 和 bkgo0 相 加 RooArgList为信号和本底的事例数，可以通过拟合得到具体的事例数

→ 画出拟合结果

运行结果


A RooPlot of "M$_{\pi^+\pi^-\pi^0}$ (GeV/c^2)"
Events / (0.004)
1600
1400
1200
1000
800
600
400
200
0
0.6
0.65
0.7
0.75
0.8
0.85
0.9
0.95
M$_{\pi^+\pi^-\pi^0}$ (GeV/c^2)

运行结果


```
**********
**    9 **HESSE        3500
**********
COVARIANCE MATRIX CALCULATED SUCCESSFULLY
FCN=-360148 FROM HESSE     STATUS=OK             62 CALLS          314 TOTAL
                    EDM=2.59207e-05    STRATEGY= 1      ERROR MATRIX ACCURATE
 EXT PARAMETER                                INTERNAL      INTERNAL
 NO.   NAME      VALUE            ERROR       STEP SIZE       VALUE
  1  mean0      -6.92184e-04   1.78943e-04   7.32605e-04  -6.92190e-03
  2  nbkg        2.30344e+04   1.78863e+02   2.69154e-03  -7.87064e-02
  3  nsig        1.05995e+04   1.39871e+02   2.43186e-03  -6.13852e-01
  4  p0          1.17803e+00   7.98795e-03   1.47813e-03   6.29839e-01
  5  p1          2.94004e-01   1.16601e-02   1.41953e-03   1.47537e-01
  6  p2          4.54275e-02   8.42510e-03   1.23438e-03   2.27157e-02
  7  sigma0      1.03433e-02   2.07064e-04   2.55629e-03  -2.22566e+00
                              ERR DEF= 0.5
EXTERNAL ERROR MATRIX.    NDIM=  25    NPAR=  7    ERR DEF=0.5
 3.202e-08 -1.886e-03  1.888e-03  3.484e-08  1.246e-07  1.607e-07 -4.077e-09
-1.886e-03  3.199e+04 -8.953e+03 -3.401e-01 -6.805e-01 -3.206e-01  1.003e-02
 1.888e-03 -8.953e+03  1.956e+04  3.401e-01  6.805e-01  3.206e-01 -1.004e-02
 3.484e-08 -3.401e-01  3.401e-01  6.381e-05  6.390e-05  3.638e-05 -3.736e-07
 1.246e-07 -6.805e-01  6.805e-01  6.390e-05  1.360e-04  6.861e-05 -7.696e-07
 1.607e-07 -3.206e-01  3.206e-01  3.638e-05  6.861e-05  7.098e-05 -3.710e-07
-4.077e-09  1.003e-02 -1.004e-02 -3.736e-07 -7.696e-07 -3.710e-07  4.288e-08
PARAMETER  CORRELATION COEFFICIENTS
      NO.  GLOBAL      1      2      3      4      5      6      7
       1  0.15548   1.000 -0.059  0.075  0.024  0.060  0.107 -0.110
       2  0.42533  -0.059  1.000 -0.358 -0.238 -0.326 -0.213  0.271
       3  0.51472   0.075 -0.358  1.000  0.304  0.417  0.272 -0.347
       4  0.69237   0.024 -0.238  0.304  1.000  0.686  0.541 -0.226
       5  0.81386   0.060 -0.326  0.417  0.686  1.000  0.698 -0.319
       6  0.70743   0.107 -0.213  0.272  0.541  0.698  1.000 -0.213
       7  0.42079  -0.110  0.271 -0.347 -0.226 -0.319 -0.213  1.000
```

进阶操作二

中国科学技术大学 University of Science and Technology of China

- 在实际工作当中，有时候某些pdf是没法用公式去描述的，找不到或者不存在公式去描述(或者说我就是不想用公式)，而我们需要这些PDF，我们就会想办法在物理上产生相近的PDF。比如我们可以从信号MC，收集一些事例构成dataset，然后由dataset去产生这个PDF。这种方法可以由任意的 dataset 来生成对应的PDF。

复杂例子1.1

- vi omegasigmcfit1.cxx

```
using namespace RooFit;
void omegasigmcfit1()
{

  //here import my data
  TFile *f_data = new TFile("sample.root");
  TTree *t_data = (TTree*)f_data->Get("GammaOmegaPhi");
  //////////////////////////////////////////////////
  RooRealVar momega("momega","M_{#pi^{+}#pi^{-}#pi^{0}} (GeV/c^{2})",0.582,0.982);
  RooDataSet data("data","data",t_data,momega);
  ////////////////sigpdf//////////////////////////
  TFile *f_mc = new TFile("myshape.root");
  TTree *t_mc = (TTree*)f_mc->Get("GammaOmegaPhi");
  RooDataSet signalmc("signalmc", "signalmc", t_mc, momega);
  RooKeysPdf somegapdf("sigPdf", "sigpdf",  momega, signalmc, RooKeysPdf::MirrorBoth, 1);



  RooRealVar mean0("mean0","mean0",0,-0.1,0.1);
  RooRealVar sigma0("sigma0","sigma0",0.1,0,0.1);
  RooGaussian gausss0("gauss0","gauss0",momega,mean0,sigma0);
  RooFFTConvPdf conv1("conv1", "conv1", momega, somegapdf, gausss0);
  ////////////////////poly////////////////////
  RooRealVar p0("p0", "", 1.3,-2,2);
  RooRealVar p1("p1", "", 0.6,-2,2);
  RooRealVar p2("p2", "", 0.2,-2,2);
  RooChebychev bkgo0("bkgo0", "bkgo0", momega, RooArgList(p0,p1,p2));
  //////////////////////////////
  RooRealVar nsig("nsig","nsig",19000,0,50000);
  RooRealVar nbkg("nbkg","nbkg",13000,0,50000);

  RooAddPdf summomega("sumomega", "sumomega", RooArgList(conv1,bkgo0), RooArgList(nsig,nbkg));
  summomega.fitTo(data);





  RooPlot* momegaframe = momega.frame();


  TCanvas *c1 = new TCanvas("c1","a canvas",0,0,1200,800);

```

这里和上面的例子的区别是，把BW分布，换成了由我们自己的的dataset生成的一个PDF

复杂例子1.2

University of Science and Technology of China

- vi omegasigmcfit.cxx

```
using namespace RooFit;
void omegasigmcfit()
{

  //here import my data
  TFile *f_data = new TFile("sample.root");
  TTree *t_data = (TTree*)f_data->Get("GammaOmegaPhi");
  //////////////////////////////////////////////////
  RooRealVar momega("momega","M_{#omega} (GeV/c^{2})",0.582,0.982);
  RooDataSet data("data","data",t_data,momega);
  ////////////////sighistpdf/////////////
  TH1F *moss = new TH1F("moss", "", 200, 0.582, 0.982);//momega signalmc shape
  TFile *f_mc = new TFile("myshape.root");
  TTree *t_mc = (TTree*)f_mc->Get("GammaOmegaPhi");
  double smomega;
  t_mc -> SetBranchAddress("momega",&smomega);
  int EntNum = t_mc -> GetEntries();
  for(int i = 0; i < EntNum ; i++)
  {
    t_mc -> GetEntry(i);
    moss -> Fill(smomega);
  }
  RooDataHist somegahist("somegahist", "somegahist",momega, moss);
  RooHistPdf  somegapdf ("somegapdf","somegapdf",momega, somegahist, 4);



  RooRealVar mean0("mean0","mean0",0,-0.1,0.1);
  RooRealVar sigma0("sigma0","sigma0",0.1,0,0.1);
  RooGaussian gausss0("gauss0","gauss0",momega,mean0,sigma0);
  RooFFTConvPdf conv1("conv1", "conv1", momega, somegapdf, gausss0);
  ///////////////////poly////////////////////
  RooRealVar p0("p0", "", 1.3,-2,2);
  RooRealVar p1("p1", "", 0.6,-2,2);
  RooRealVar p2("p2", "", 0.2,-2,2);
  RooChebychev bkgo0("bkgo0", "bkgo0", momega, RooArgList(p0,p1,p2));
  //////////////////////////////
  RooRealVar nsig("nsig","nsig",19000,0,50000);
  RooRealVar nbkg("nbkg","nbkg",13000,0,50000);

  RooAddPdf summomega("sumomega", "sumomega", RooArgList(conv1,bkgo0), RooArgList(nsig,nbkg));
  summomega.fitTo(data);

```

这是另一种生成PDF的方法，即先把数据填到一个hist里面，再由这个hist来生成一个PDF。该方法较上一页的方法相比稍微粗糙一些，但是快，在生成PDF的数据量很大的时候适用。

更多

- 拟合还有很多可以的操作，比如
  - ✓ 需要拟合的数据量巨大的时候，可以把数据分成bin拟合，速度会大大加快
  - ✓ 如果需要同时进行多个量拟合的时候，会有二维单位的拟合，即那种联合概率密度函数。
  - ✓ dataset很难拟合上的话，可以进行多次迭代拟合(拟合本身就是一种迭代！)，以得到更有的结果。
  - ✓ 还可以自己编写PDF函数，写成头文件或者写成包之类的，后面可以自己用。
  - ✓ blablabla

总结

- 需要进行资料查阅的话，可以到ROOT的官网里面的reference里面去搜索，也可以直接在bing搜索某个函数。有问题解决不了的话，不要自己一直纠结，狠狠抓师兄们！(root作为工具我们的要求是熟练地用，而不需要自己去浪费太多时间)
- ROOT自带的tutorial就很好用，里面有很多东西,大家可以把整个tutorial目录cp到自己的目录下，随便运行进行尝试(里面有roofit的部分，也有各种别的部分):
  - ✓ cp $ROOTSYS/tutorials ./

本次入门教学到此圆满结束！！
感谢各位的参加！！