Exercise-7

PRACTICAL CLASS 7

for the Course

Laboratorio Analisi Dati

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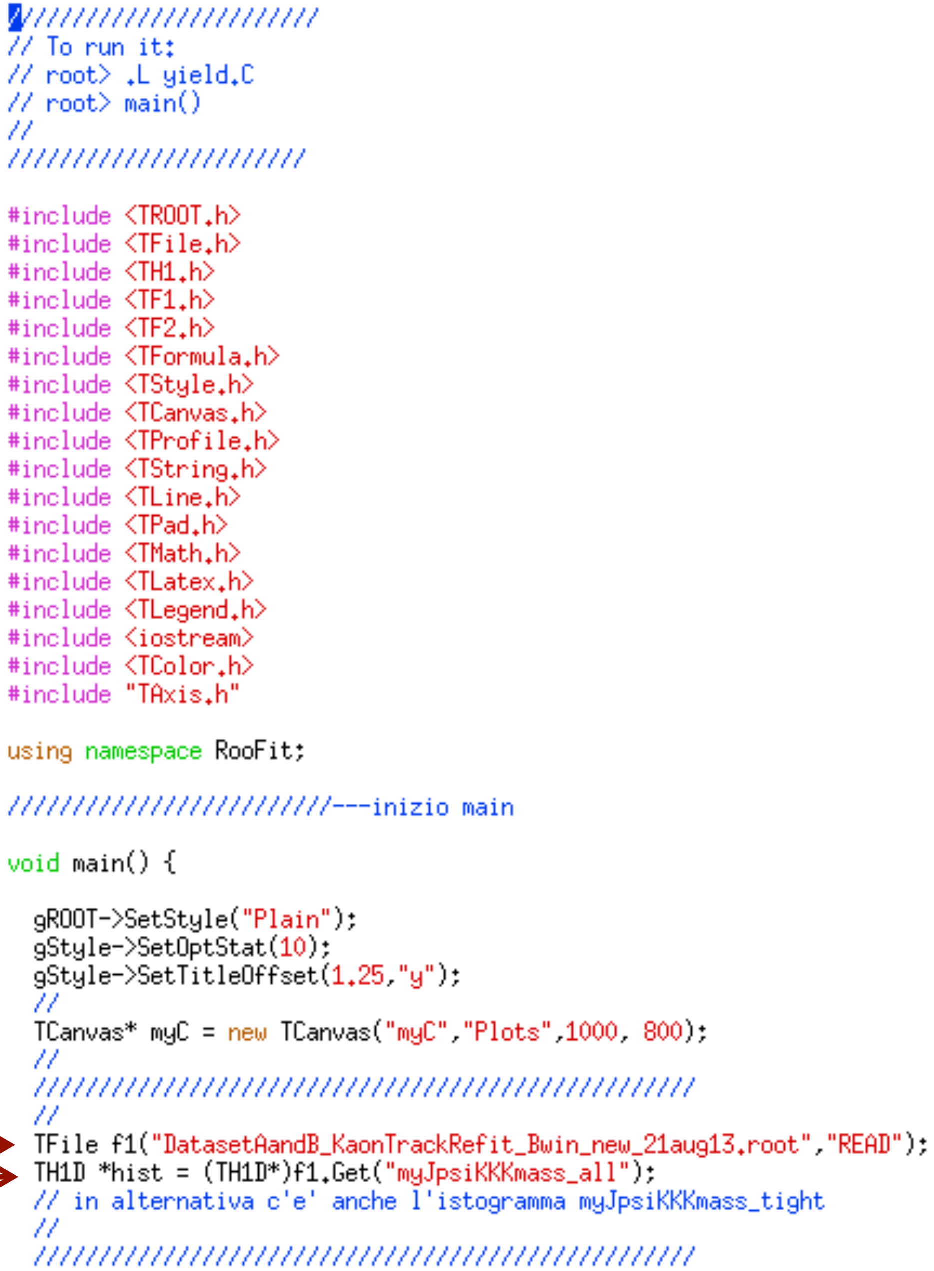
Prof. A.Pompili

Here follows the code (RooFit macro *yield.C*) for this exercise.

The first part is:

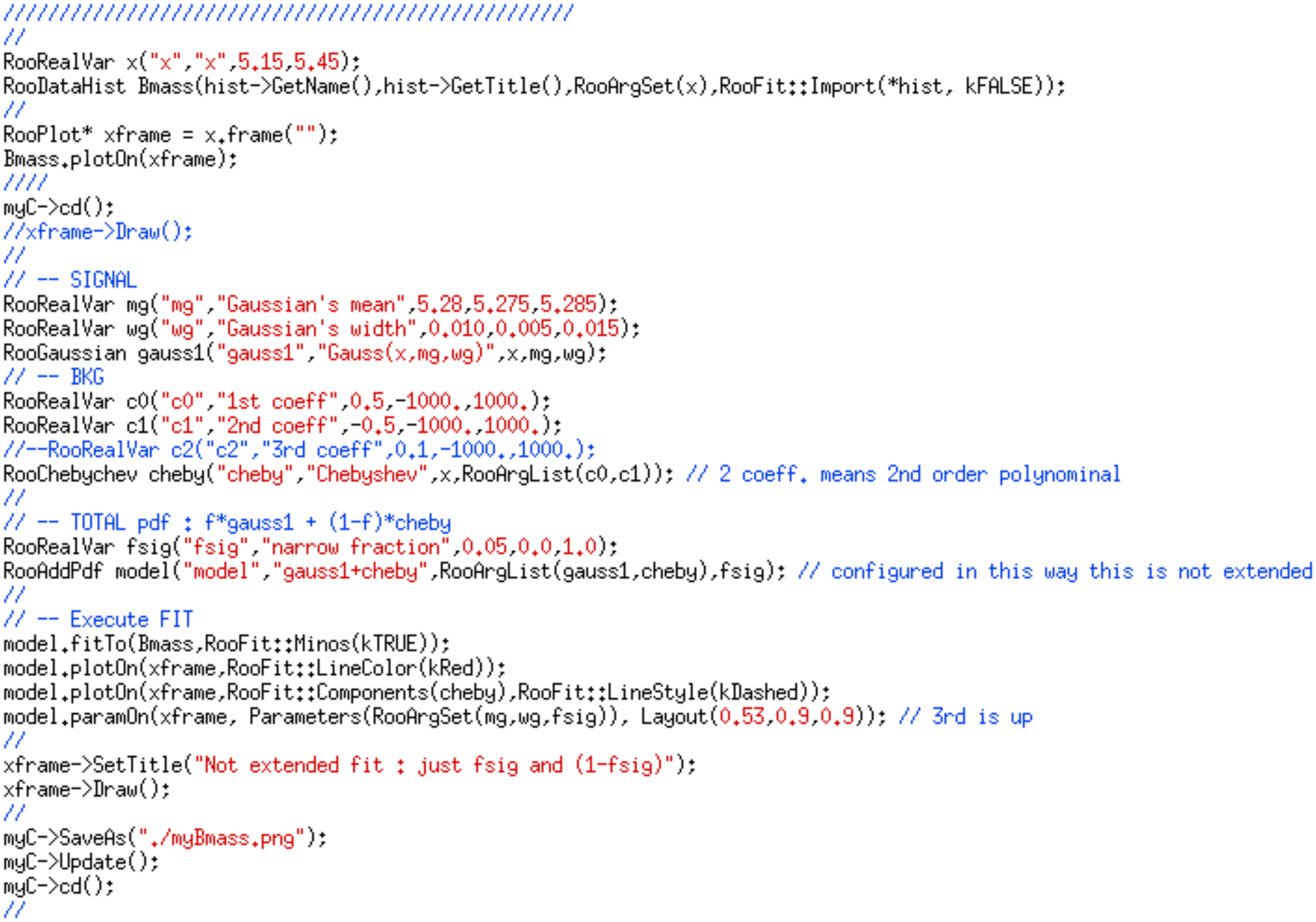


```
////////////////////////
// To run it:
// root> .L yield.C
// root> main()
//
///////////////////////

#include <TROOT.h>
#include <TFile.h>
#include <TH1.h>
#include <TF1.h>
#include <TF2.h>
#include <TFormula.h>
#include <TStyle.h>
#include <TCanvas.h>
#include <TProfile.h>
#include <TString.h>
#include <TLine.h>
#include <TPad.h>
#include <TMath.h>
#include <TLatex.h>
#include <TLegend.h>
#include <iostream>
#include <TColor.h>
#include "TAxis.h"

using namespace RooFit;

/////////////////////////---inizio main

void main() {

  gROOT->SetStyle("Plain");
  gStyle->SetOptStat(10);
  gStyle->SetTitleOffset(1.25,"y");
  //
  TCanvas* myC = new TCanvas("myC","Plots",1000, 800);
  //
  ///////////////////////////////////////////////////
  //
  TFile f1("DatasetAandB_KaonTrackRefit_Bwin_new_21aug13.root","READ");
  TH1D *hist = (TH1D*)f1.Get("myJpsiKKKmass_all");
  // in alternativa c'e' anche l'istogramma myJpsiKKKmass_tight
  //
  ///////////////////////////////////////////////////
```

Input file

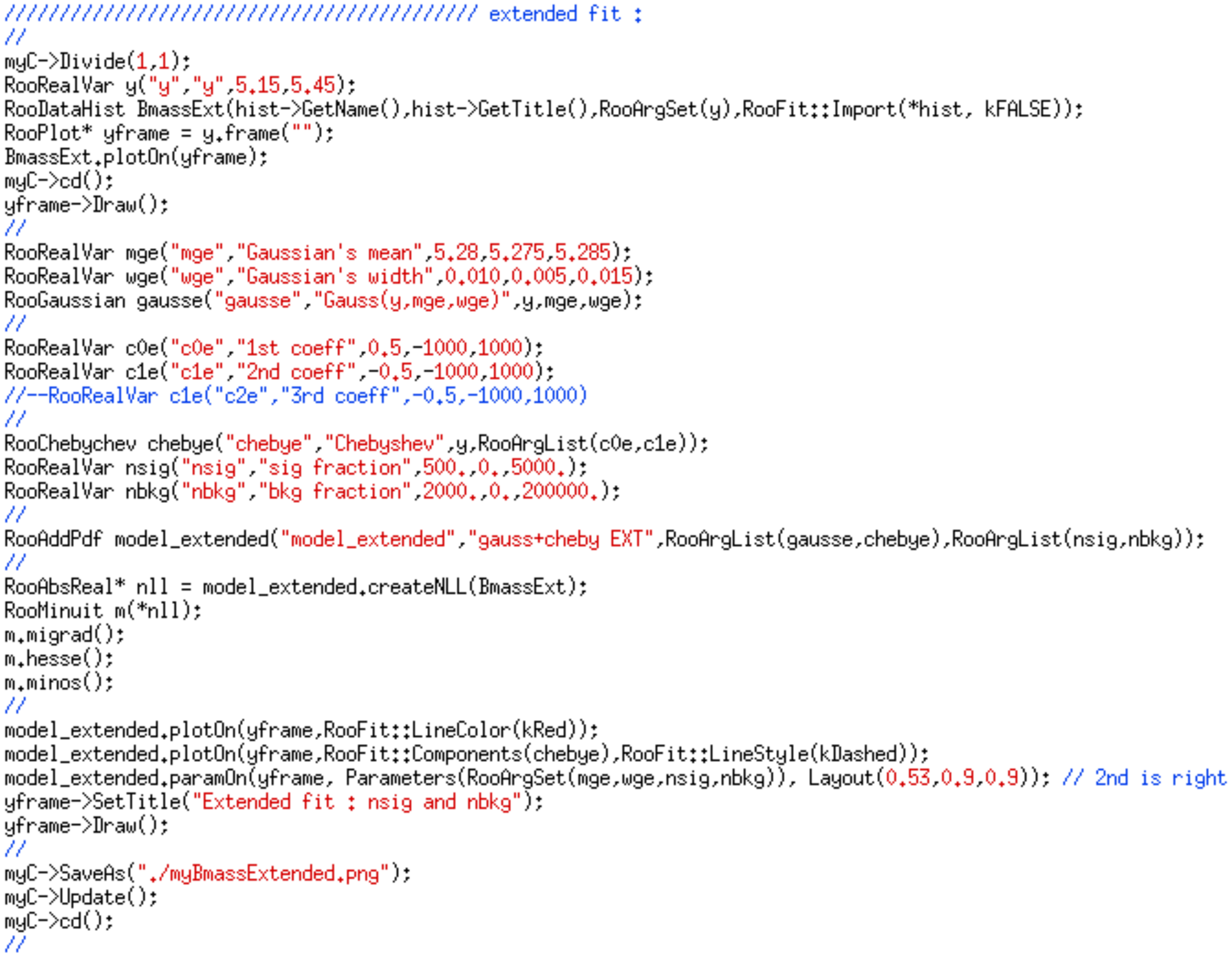
Histogram to work on

Part of the code to execute the not extended ML fit :



```
///////////////////////////////////////////////////
//
RooRealVar x("x","x",5.15,5.45);
RooDataHist Bmass(hist->GetName(),hist->GetTitle(),RooArgSet(x),RooFit::Import(*hist, kFALSE));
//
RooPlot* xframe = x.frame("");
Bmass.plotOn(xframe);
////
myC->cd();
//xframe->Draw();
//
// -- SIGNAL
RooRealVar mg("mg","Gaussian's mean",5.28,5.275,5.285);
RooRealVar wg("wg","Gaussian's width",0.010,0.005,0.015);
RooGaussian gauss1("gauss1","Gauss(x,mg,wg)",x,mg,wg);
// -- BKG
RooRealVar c0("c0","1st coeff",0.5,-1000.,1000.);
RooRealVar c1("c1","2nd coeff",-0.5,-1000.,1000.);
//--RooRealVar c2("c2","3rd coeff",0.1,-1000.,1000.);
RooChebychev cheby("cheby","Chebyshev",x,RooArgList(c0,c1)); // 2 coeff. means 2nd order polynominal
//
// -- TOTAL pdf : f*gauss1 + (1-f)*cheby
RooRealVar fsig("fsig","narrow fraction",0.05,0.0,1.0);
RooAddPdf model("model","gauss1+cheby",RooArgList(gauss1,cheby),fsig); // configured in this way this is not extended
//
// -- Execute FIT
model.fitTo(Bmass,RooFit::Minos(kTRUE));
model.plotOn(xframe,RooFit::LineColor(kRed));
model.plotOn(xframe,RooFit::Components(cheby),RooFit::LineStyle(kDashed));
model.paramOn(xframe, Parameters(RooArgSet(mg,wg,fsig)), Layout(0.53,0.9,0.9)); // 3rd is up
//
xframe->SetTitle("Not extended fit : just fsig and (1-fsig)");
xframe->Draw();
//
myC->SaveAs("./myBmass.png");
myC->Update();
myC->cd();
//
```

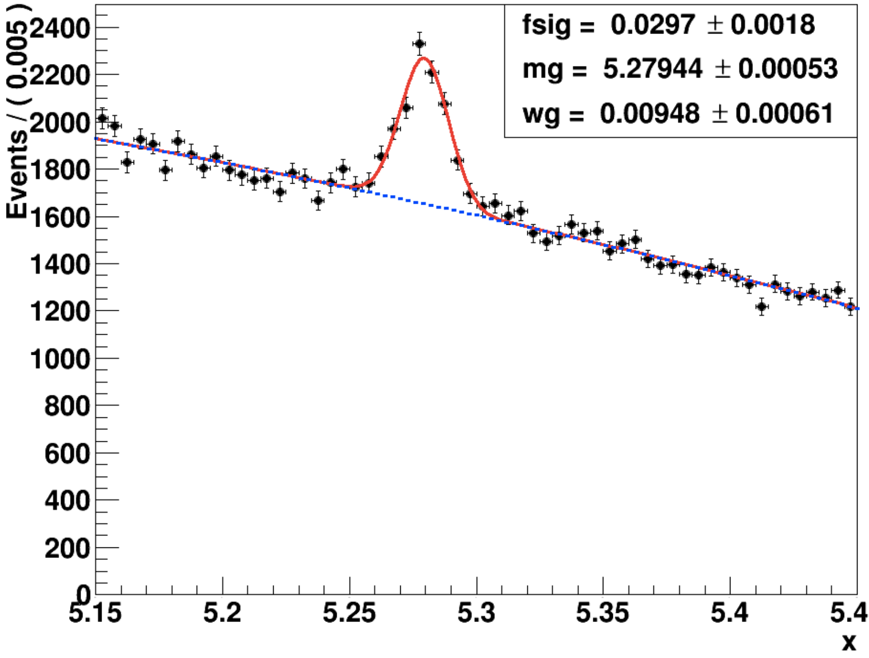
Part of the code to execute the extended ML fit :



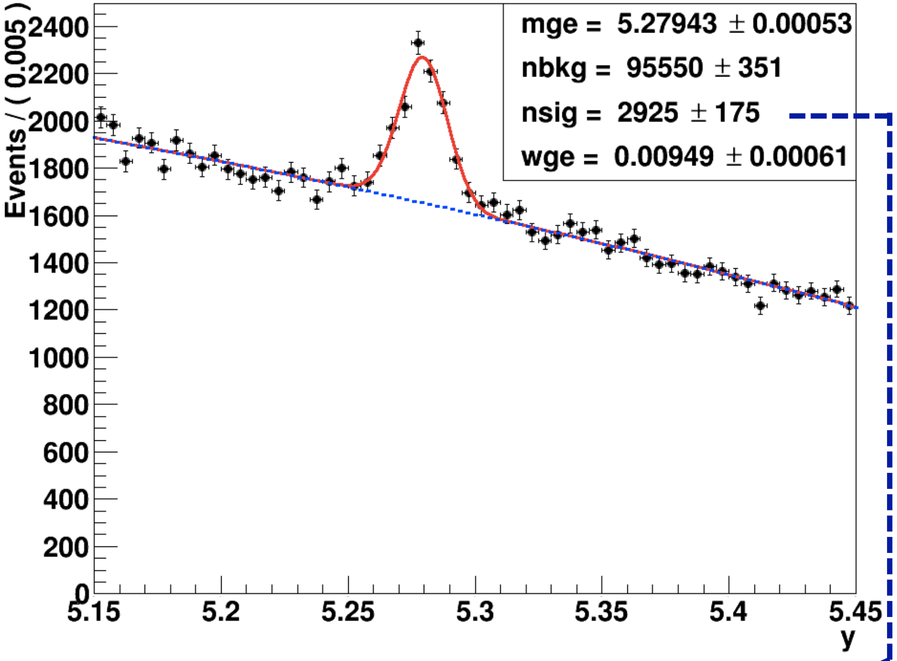
```
//////////////////////////////////////////// extended fit :
//
myC->Divide(1,1);
RooRealVar y("y","y",5.15,5.45);
RooDataHist BmassExt(hist->GetName(),hist->GetTitle(),RooArgSet(y),RooFit::Import(*hist, kFALSE));
RooPlot* yframe = y.frame("");
BmassExt.plotOn(yframe);
myC->cd();
yframe->Draw();
//
RooRealVar mge("mge","Gaussian's mean",5.28,5.275,5.285);
RooRealVar wge("wge","Gaussian's width",0.010,0.005,0.015);
RooGaussian gausse("gausse","Gauss(y,mge,wge)",y,mge,wge);
//
RooRealVar c0e("c0e","1st coeff",0.5,-1000,1000);
RooRealVar c1e("c1e","2nd coeff",-0.5,-1000,1000);
//--RooRealVar c1e("c2e","3rd coeff",-0.5,-1000,1000)
//
RooChebychev chebye("chebye","Chebyshev",y,RooArgList(c0e,c1e));
RooRealVar nsig("nsig","sig fraction",500.,0.,5000.);
RooRealVar nbkg("nbkg","bkg fraction",2000.,0.,200000.);
//
RooAddPdf model_extended("model_extended","gauss+cheby EXT",RooArgList(gausse,chebye),RooArgList(nsig,nbkg));
//
RooAbsReal* nll = model_extended.createNLL(BmassExt);
RooMinuit m(*nll);
m.migrad();
m.hesse();
m.minos();
//
model_extended.plotOn(yframe,RooFit::LineColor(kRed));
model_extended.plotOn(yframe,RooFit::Components(chebye),RooFit::LineStyle(kDashed));
model_extended.paramOn(yframe, Parameters(RooArgSet(mge,wge,nsig,nbkg)), Layout(0.53,0.9,0.9)); // 2nd is right
yframe->SetTitle("Extended fit : nsig and nbkg");
yframe->Draw();
//
myC->SaveAs("./myBmassExtended.png");
myC->Update();
myC->cd();
//
```

We obtain both not-Extended & Extended ML fit :

Not extended fit : just fsig and (1-fsig)



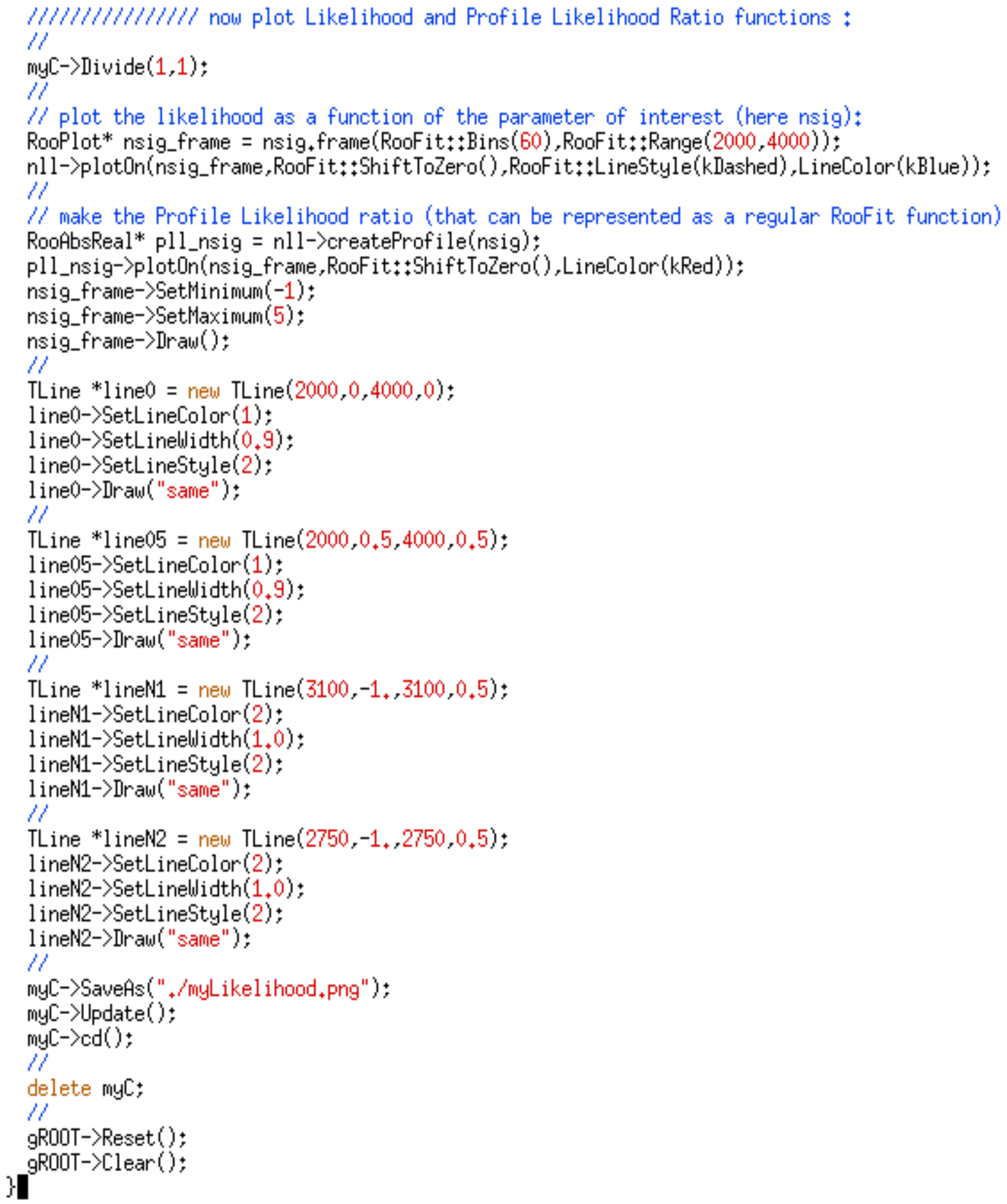
Extended fit : nsig and nbkg



You can check that difference is negligible.

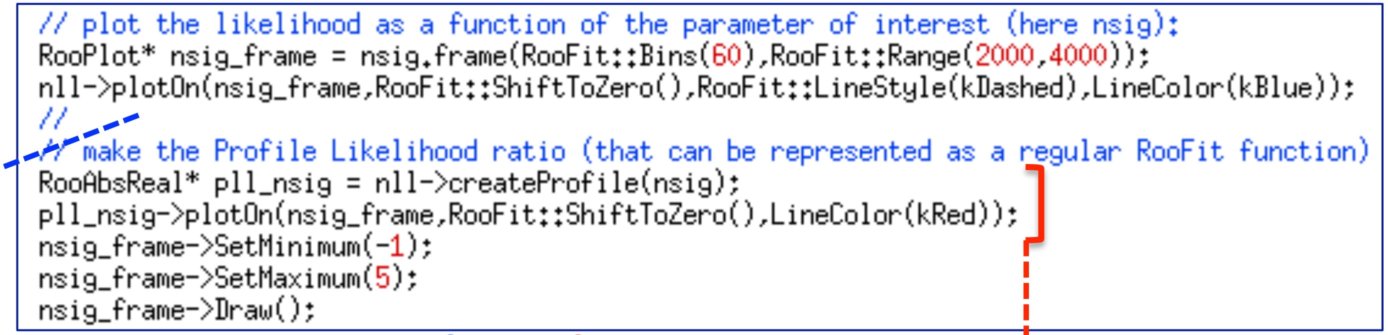
Take note of the uncertainty (by MINOS) on the yield: $2925 \pm 175 \Leftrightarrow [2750, 3100]$

Part of the code to obtain the Likelihood & the Profile Likelihood ratio for the `nsig` parameter :

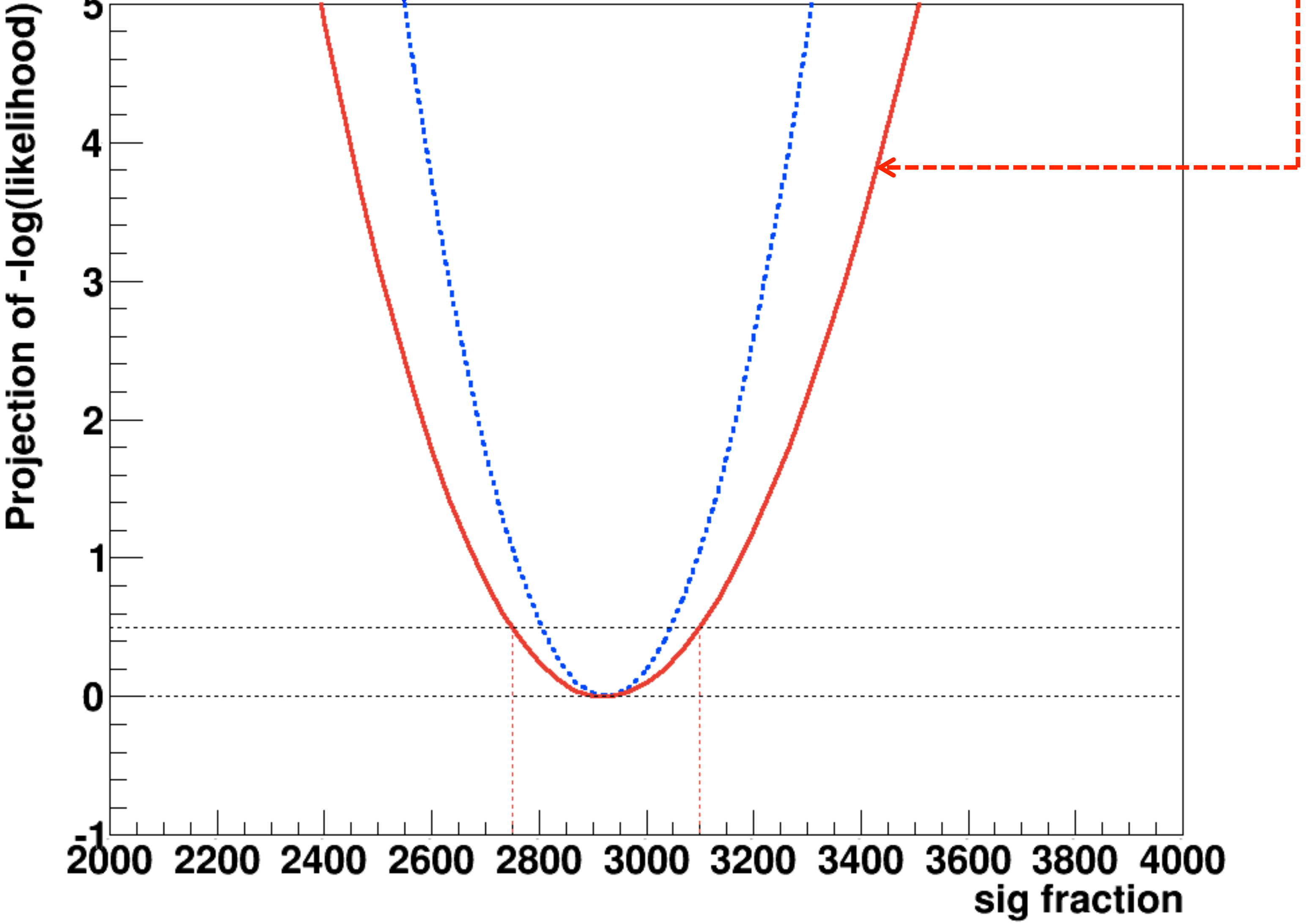


```
//////////////// now plot Likelihood and Profile Likelihood Ratio functions :
//
myC->Divide(1,1);
//
// plot the likelihood as a function of the parameter of interest (here nsig):
RooPlot* nsig_frame = nsig.frame(RooFit::Bins(60),RooFit::Range(2000,4000));
nll->plotOn(nsig_frame,RooFit::ShiftToZero(),RooFit::LineStyle(kDashed),LineColor(kBlue));
//
// make the Profile Likelihood ratio (that can be represented as a regular RooFit function)
RooAbsReal* pll_nsig = nll->createProfile(nsig);
pll_nsig->plotOn(nsig_frame,RooFit::ShiftToZero(),LineColor(kRed));
nsig_frame->SetMinimum(-1);
nsig_frame->SetMaximum(5);
nsig_frame->Draw();
//
TLine *line0 = new TLine(2000,0,4000,0);
line0->SetLineColor(1);
line0->SetLineWidth(0.9);
line0->SetLineStyle(2);
line0->Draw("same");
//
TLine *line05 = new TLine(2000,0.5,4000,0.5);
line05->SetLineColor(1);
line05->SetLineWidth(0.9);
line05->SetLineStyle(2);
line05->Draw("same");
//
TLine *lineN1 = new TLine(3100,-1.,3100,0.5);
lineN1->SetLineColor(2);
lineN1->SetLineWidth(1.0);
lineN1->SetLineStyle(2);
lineN1->Draw("same");
//
TLine *lineN2 = new TLine(2750,-1.,2750,0.5);
lineN2->SetLineColor(2);
lineN2->SetLineWidth(1.0);
lineN2->SetLineStyle(2);
lineN2->Draw("same");
//
myC->SaveAs("./myLikelihood.png");
myC->Update();
myC->cd();
//
delete myC;
//
gROOT->Reset();
gROOT->Clear();
}
```

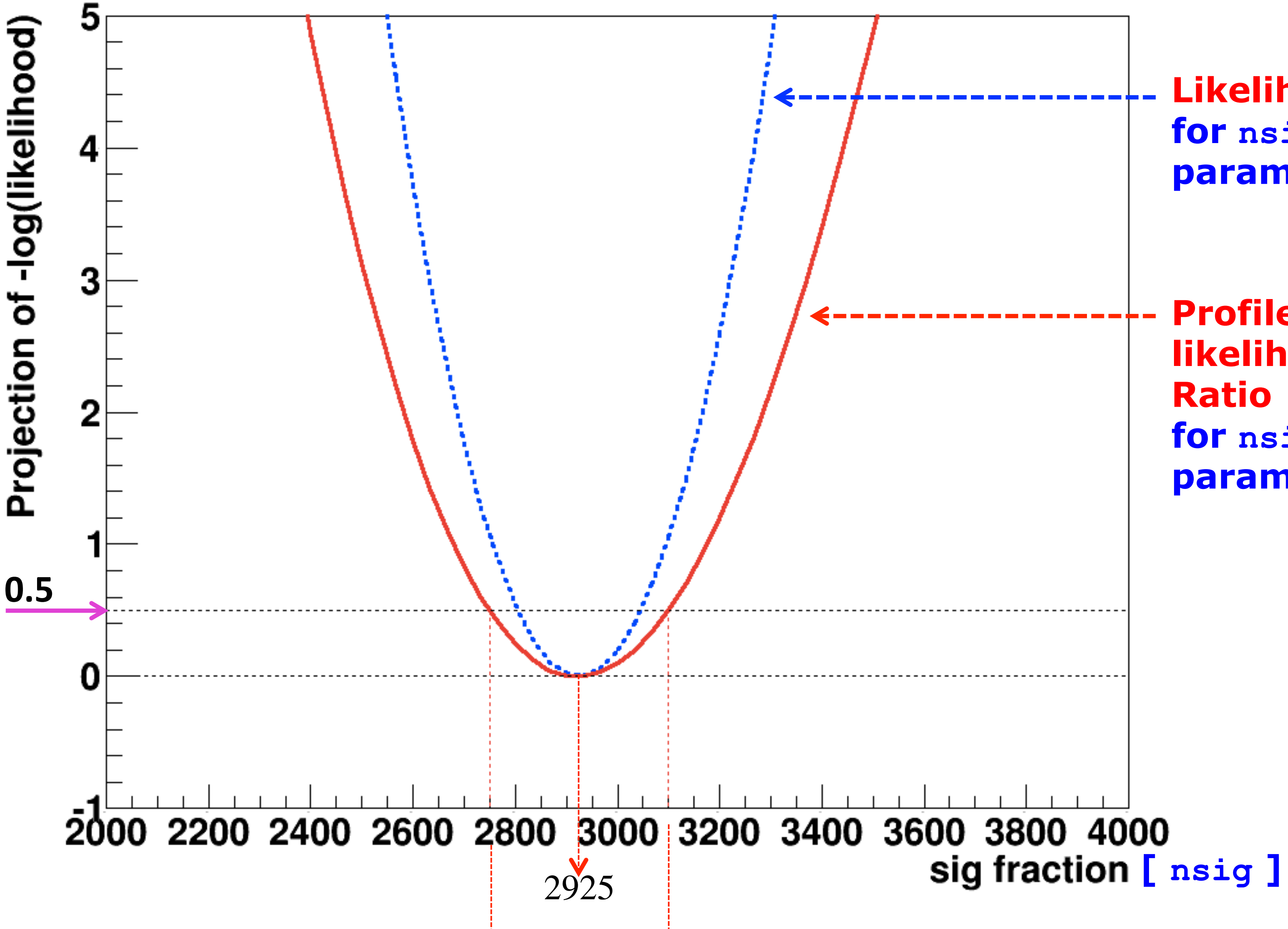
The obtained plot:



```
// plot the likelihood as a function of the parameter of interest (here nsig):
RooPlot* nsig_frame = nsig.frame(RooFit::Bins(60),RooFit::Range(2000,4000));
nll->plotOn(nsig_frame,RooFit::ShiftToZero(),RooFit::LineStyle(kDashed),LineColor(kBlue));
//
// make the Profile Likelihood ratio (that can be represented as a regular RooFit function)
RooAbsReal* pll_nsig = nll->createProfile(nsig);
pll_nsig->plotOn(nsig_frame,RooFit::ShiftToZero(),LineColor(kRed));
nsig_frame->SetMinimum(-1);
nsig_frame->SetMaximum(5);
nsig_frame->Draw();
```



The obtained plot : the best estimate for nsig and the MINOS error :



Likelihood for nsig parameter

Profile likelihood Ratio for nsig parameter

2750

3100

[From MINOS: $2925 \pm 175 \Leftrightarrow [2750, 3100]$ **]**