In [2]:
```
import ROOT
```

```
Welcome to JupyROOT 6.24/02
```

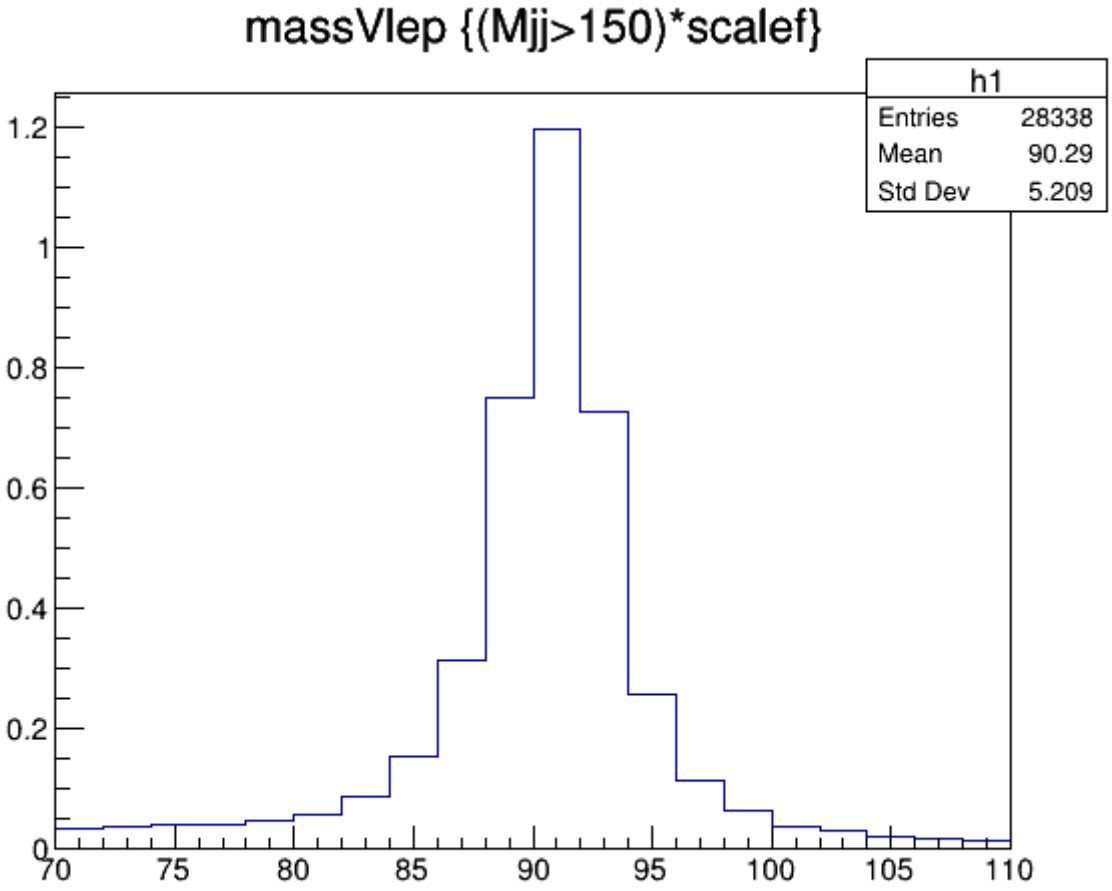
Exercise 1 - Plot Scan

In [3]:
```
fdir='/data/pubfs/pku_visitor/public_write/zajj_ori/'
```

In [104…
```
fZA_EWK=ROOT.TFile(fdir+'cutla-outZA-EWK17.root')
tree1=fZA_EWK.Get('ZPKUCandidates')
```

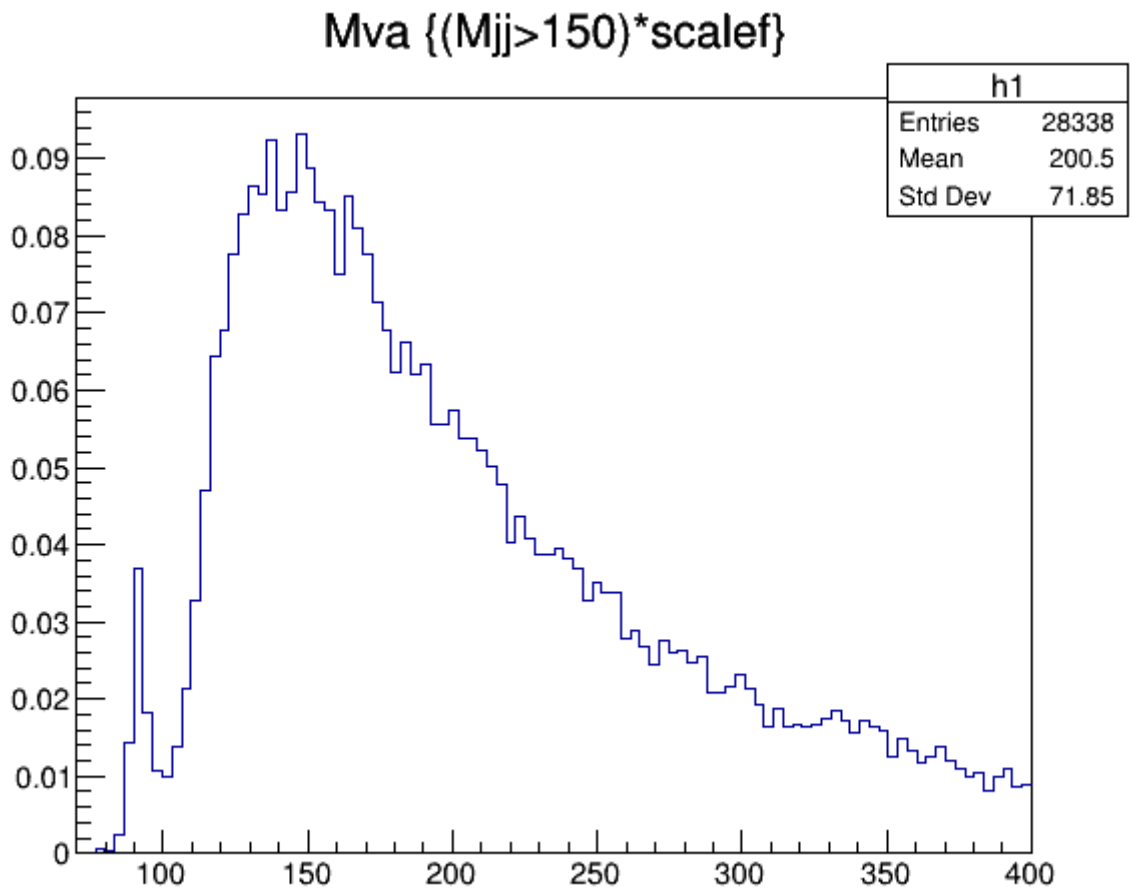
In [105…
```
c1=ROOT.TCanvas('c1','',600,500)
c1.Draw()
tree1.Draw('massVlep>>h1(20,70,110)','(Mjj>150)*scalef','HIST')
```

Out[105…
```
28338

Warning in <TCanvas::Constructor>: Deleting canvas with same name: c1
```



In [110…
```
c1=ROOT.TCanvas('c1','',600,500)
c1.Draw()
tree1.Draw('Mva>>h1(100,70,400)','(Mjj>150)*scalef','HIST')
```

Out[110…
```
28338

Warning in <TCanvas::Constructor>: Deleting canvas with same name: c1
```

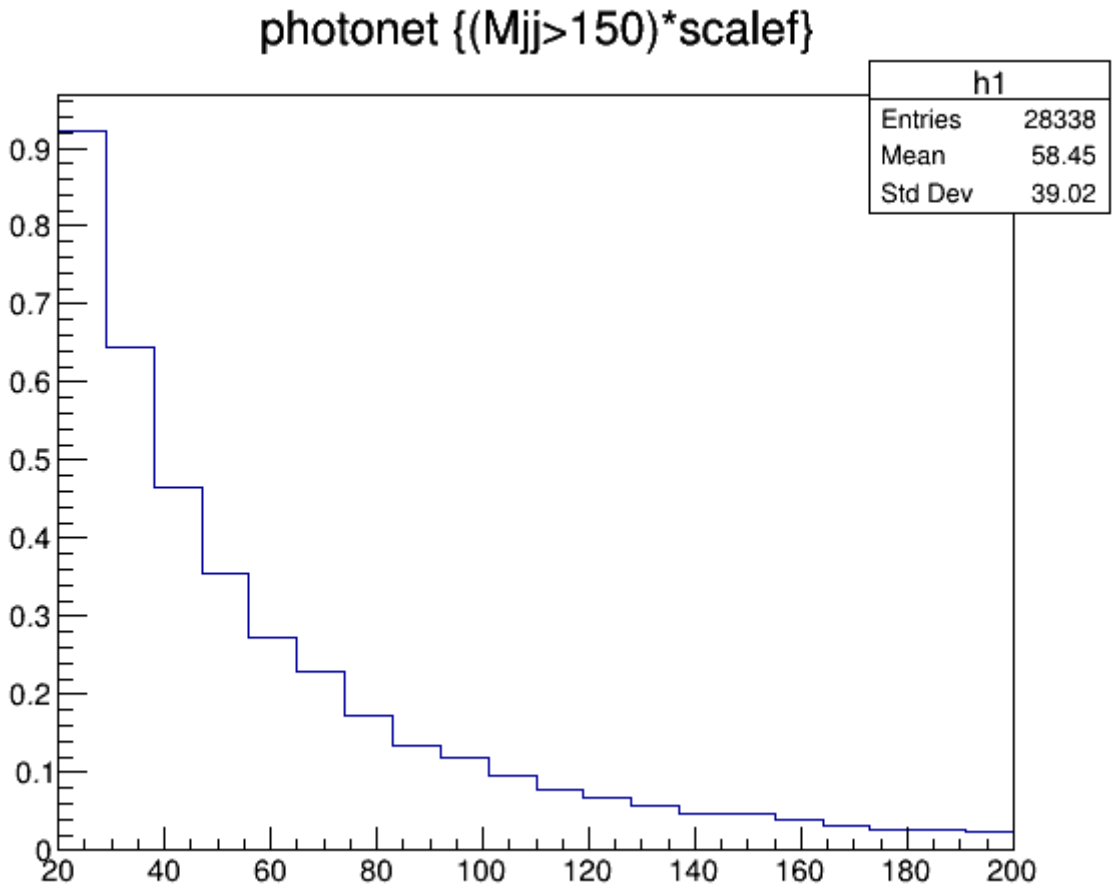


In [111…

```
c1=ROOT.TCanvas('c1','',600,500)
c1.Draw()
tree1.Draw('photonet>>h1(20,20,200)','(Mjj>150)*scalef','HIST')
```

Out[111…

```
28338

Warning in <TCanvas::Constructor>: Deleting canvas with same name: c1
```

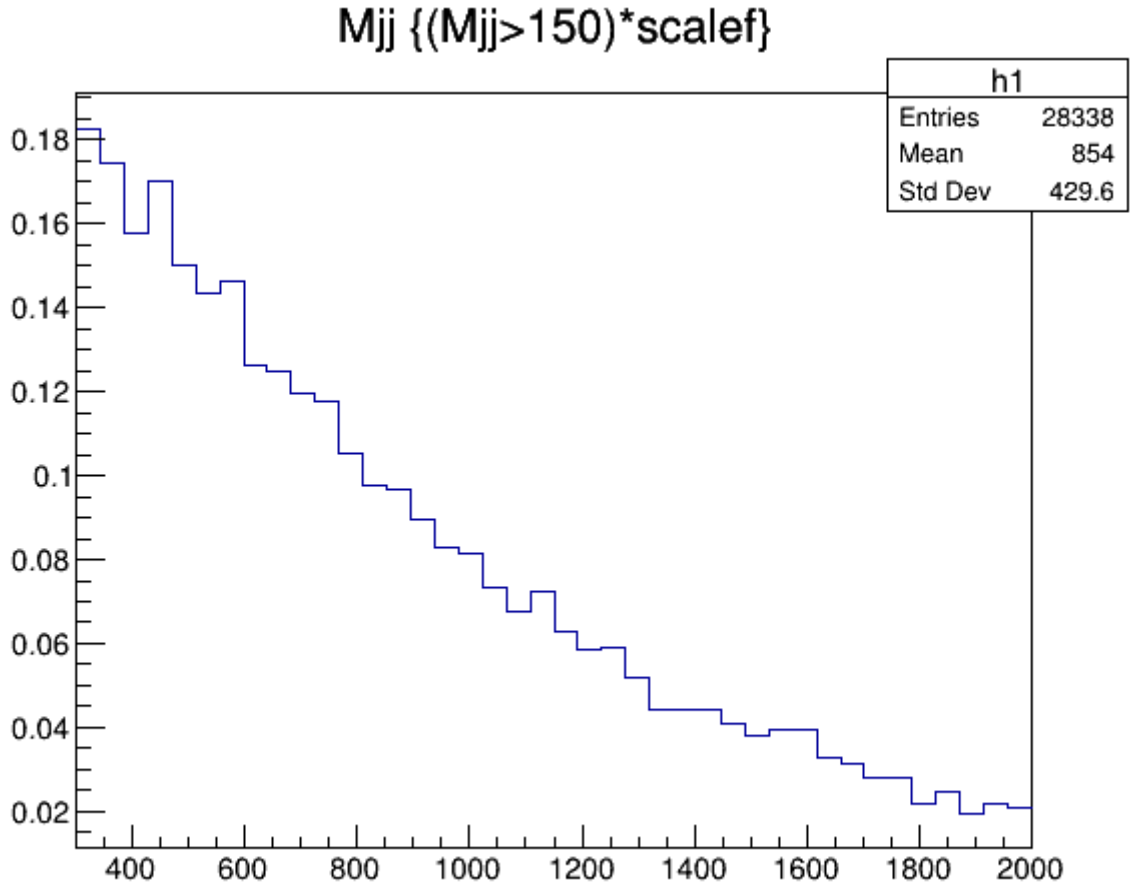


In [112…

```
c1=ROOT.TCanvas('c1','',600,500)
c1.Draw()
tree1.Draw('Mjj>>h1(40,300,2000)','(Mjj>150)*scalef','HIST')
```

Out[112…

```
28338

Warning in <TCanvas::Constructor>: Deleting canvas with same name: c1
```

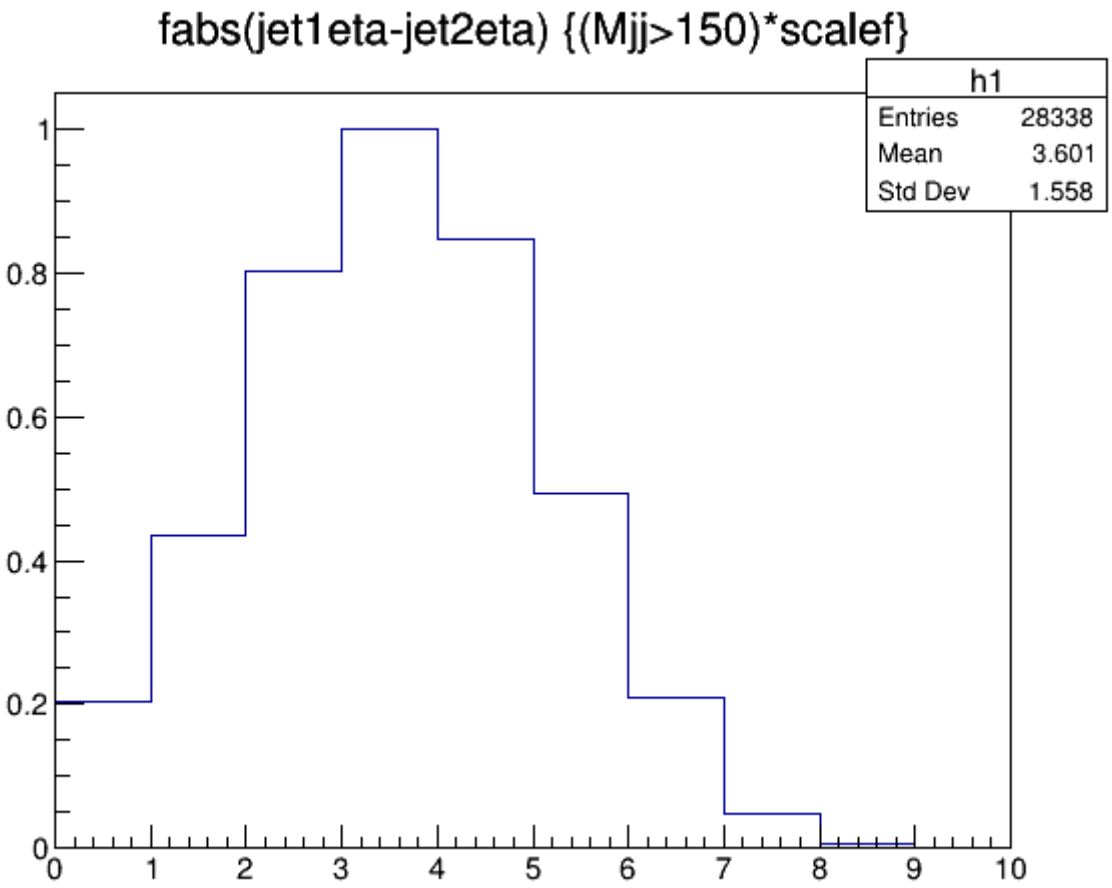


In [113…

```
c1=ROOT.TCanvas('c1','',600,500)
c1.Draw()
tree1.Draw('fabs(jet1eta-jet2eta)>>h1(10,0,10)','(Mjj>150)*scalef','HIST')
```

Out[113…

```
28338

Warning in <TCanvas::Constructor>: Deleting canvas with same name: c1
```

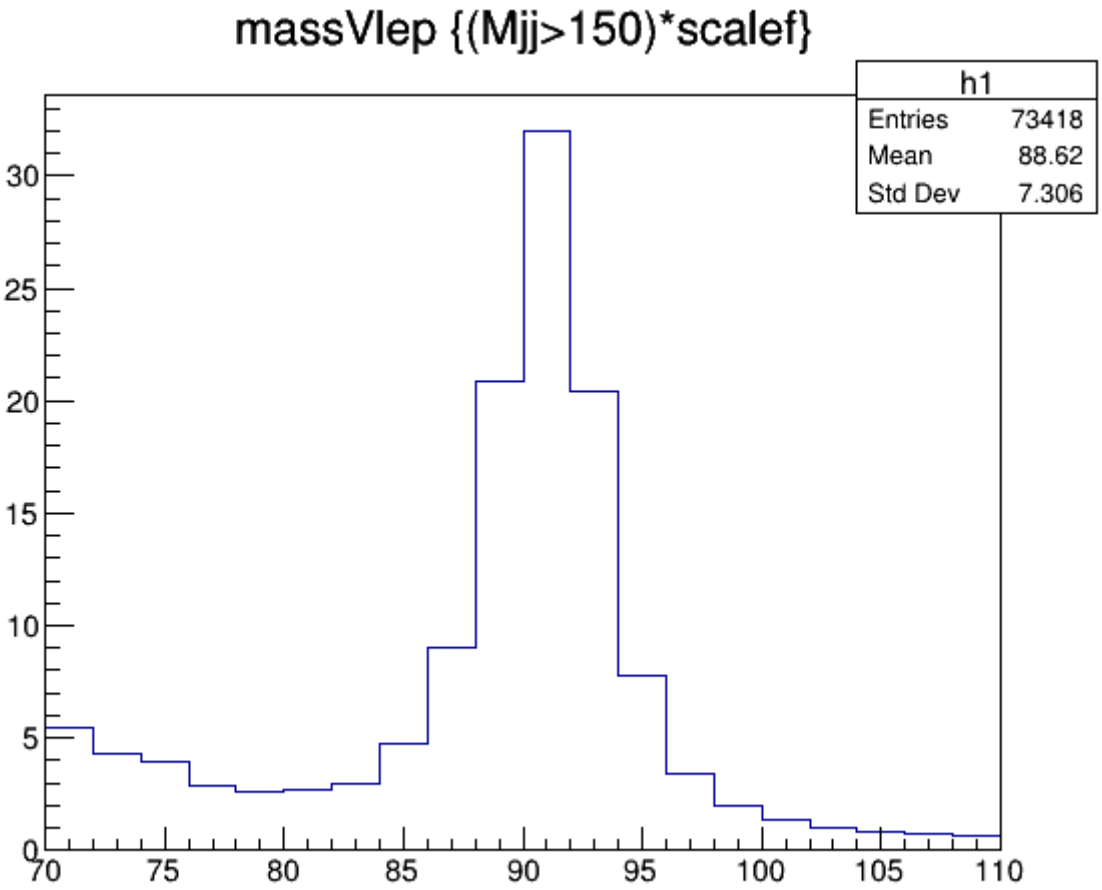


In [116…

```
fZA=ROOT.TFile(fdir+'cutla-outZA17.root')
tree2=fZA.Get('ZPKUCandidates')
c1=ROOT.TCanvas('c1','',600,500)
c1.Draw()
tree2.Draw('massVlep>>h1(20,70,110)','(Mjj>150)*scalef','HIST')
```

Out[116…

```
73418

Warning in <TCanvas::Constructor>: Deleting canvas with same name: c1
```

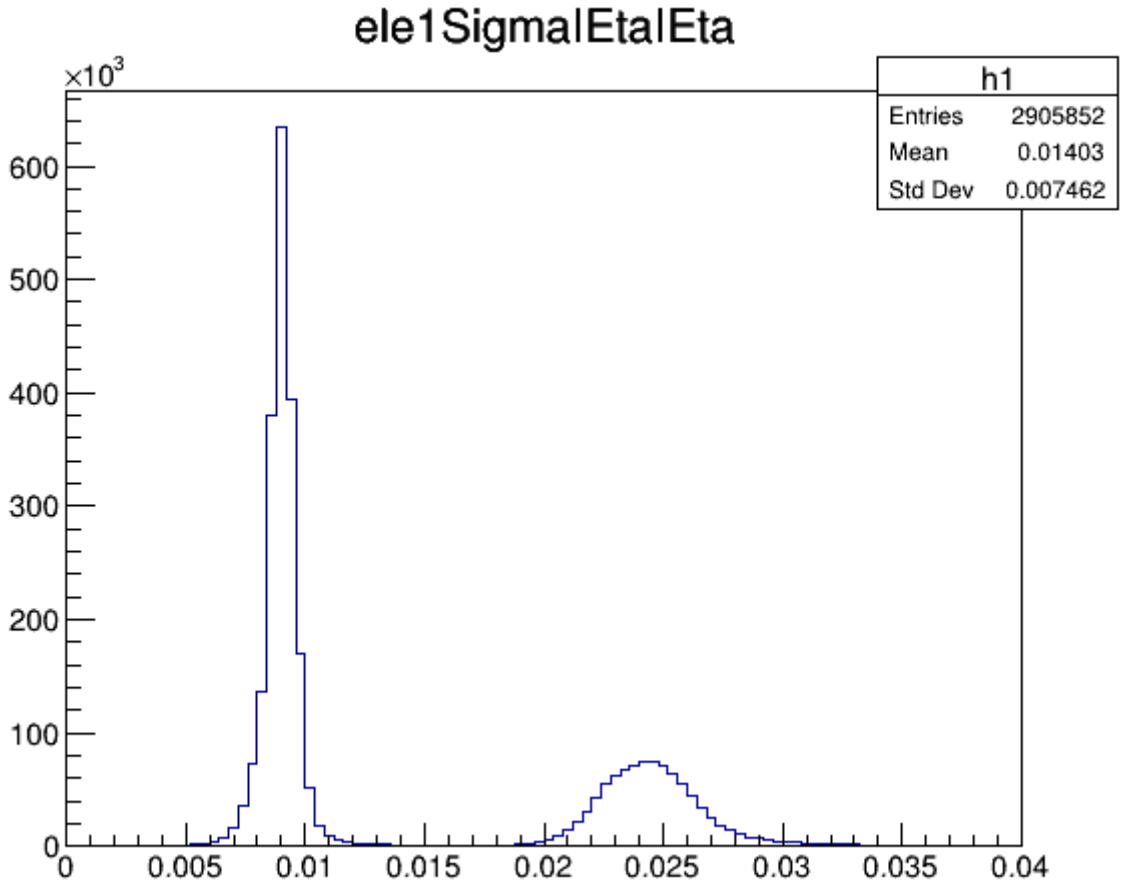


Exercise2

In [117…

```
fdy=ROOT.TFile(fdir+'dyJets_94X_massTreeV2.root')
tree3=fdy.Get('EventMassTree')
c1=ROOT.TCanvas('c1','',600,500)
c1.Draw()
tree3.Draw('ele1SigmaIEtaIEta>>h1(100,0,0.04)')
```

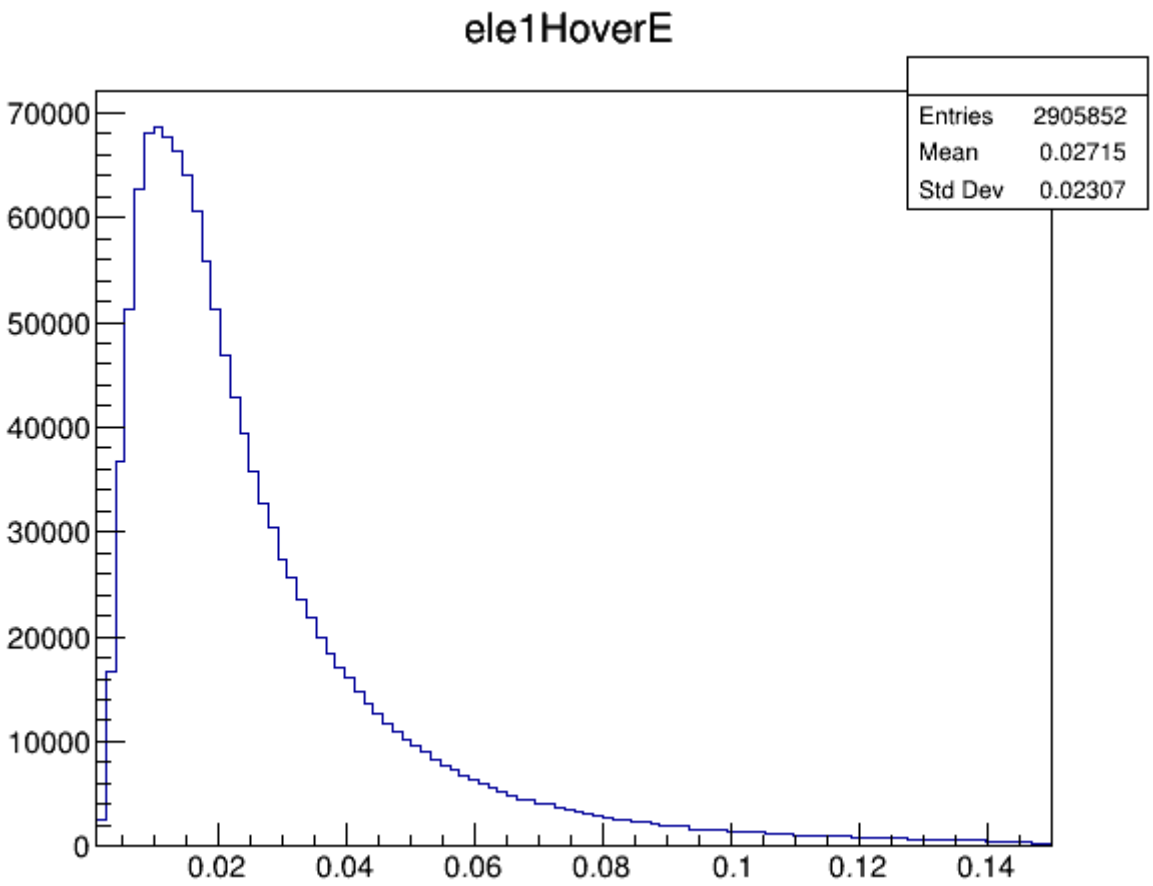
```
Warning in <TCanvas::Constructor>: Deleting canvas with same name: c1
```



In [118…

```
c1=ROOT.TCanvas('c1','',600,500)
c1.Draw()
tree3.Draw('ele1HoverE>>(100,0.001,0.15)')
```

```
Warning in <TCanvas::Constructor>: Deleting canvas with same name: c1
```

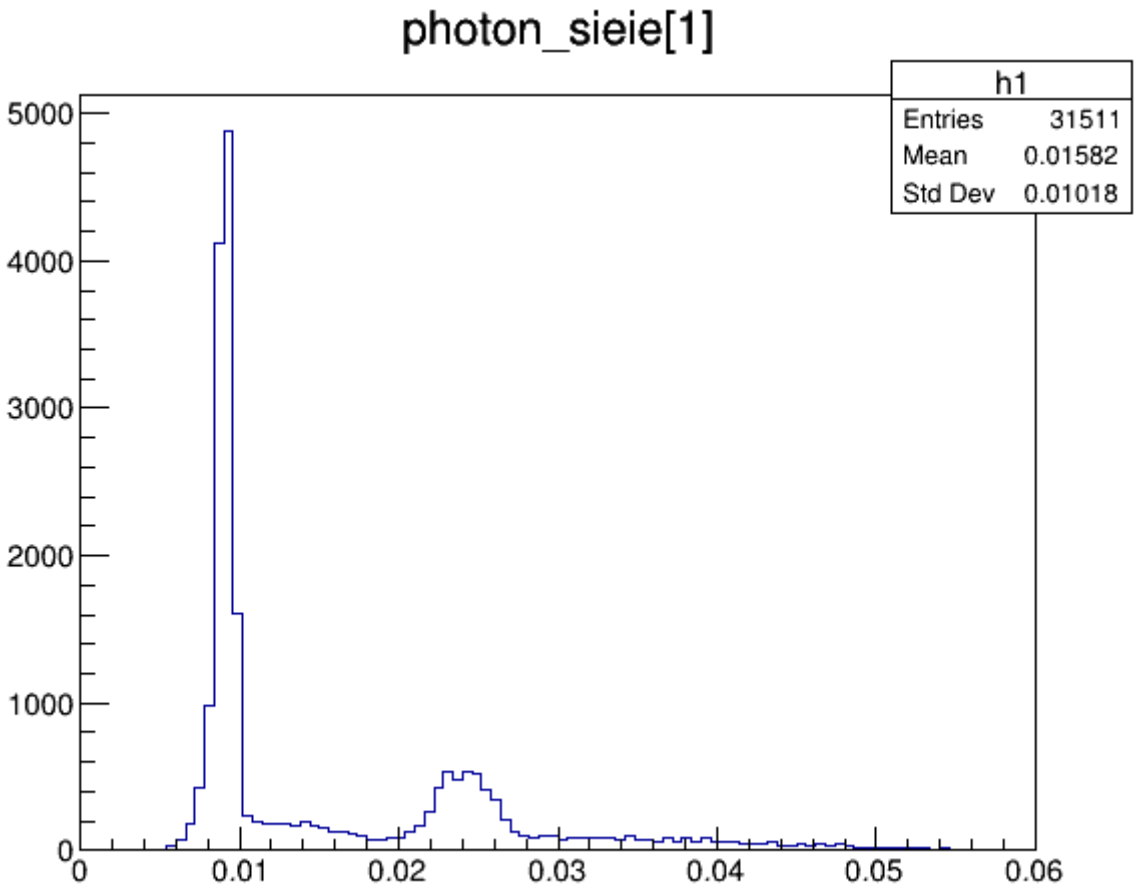


Exercise 3

In [119…

```
c1=ROOT.TCanvas('c1','',600,500)
c1.Draw()
tree1.Draw('photon_sieie[1]>>h1(100,0,0.06)')
```

```
Warning in <TCanvas::Constructor>: Deleting canvas with same name: c1
```

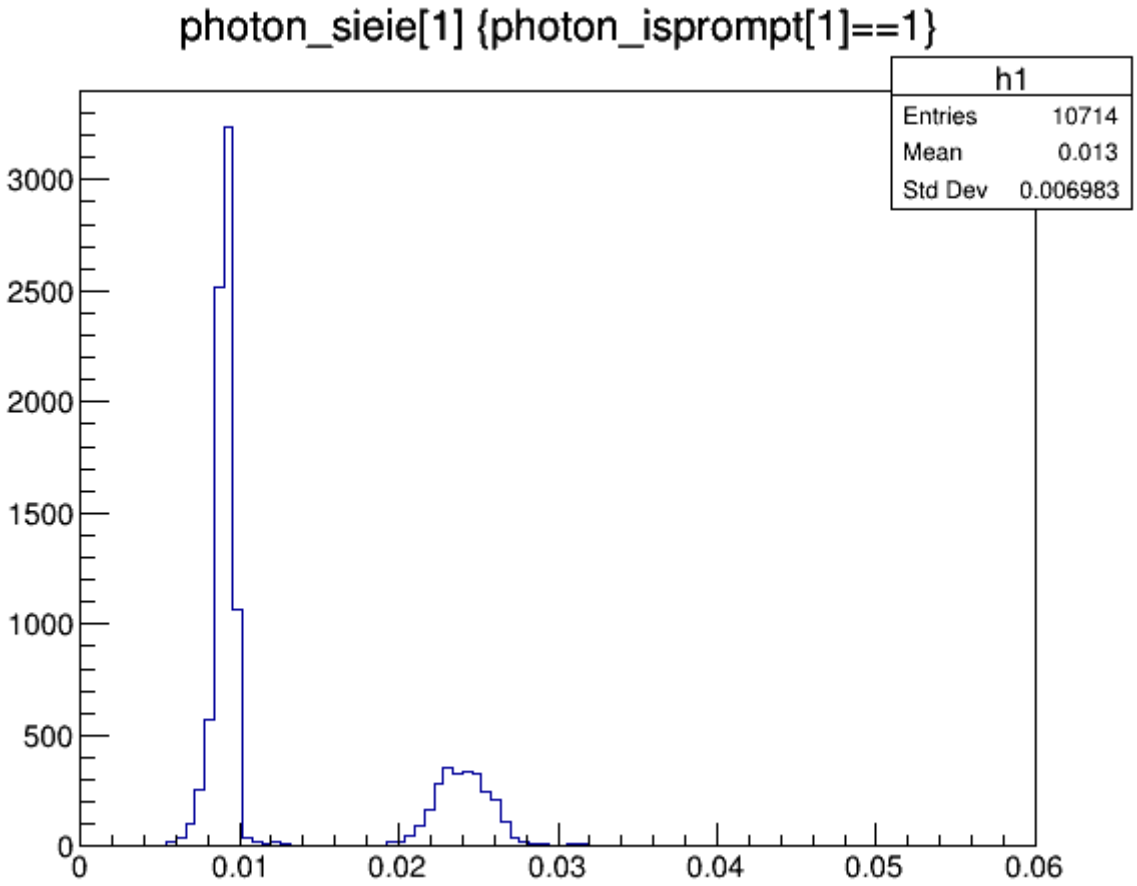


In [120…

```
c1=ROOT.TCanvas('c1','',600,500)
c1.Draw()
tree1.Draw('photon_sieie[1]>>h1(100,0,0.06)','photon_isprompt[1]==1')
```

Out[120…

```
10714

Warning in <TCanvas::Constructor>: Deleting canvas with same name: c1
```



In [145…

```
fZjets=ROOT.TFile.Open(fdir+'cutla-outDYJets18.root')
tree4=fZjets.Get('Events')
hist1=ROOT.TH1D('hist1','',10,20,200)
hist2=ROOT.TH1D('hist2','',10,20,200)

tree4.Draw("photonet>>hist1","(photon_selection==1 || photon_selection==4 ||
tree4.Draw("photonet>>hist2","(photon_selection==1 || photon_selection==4 ||
```

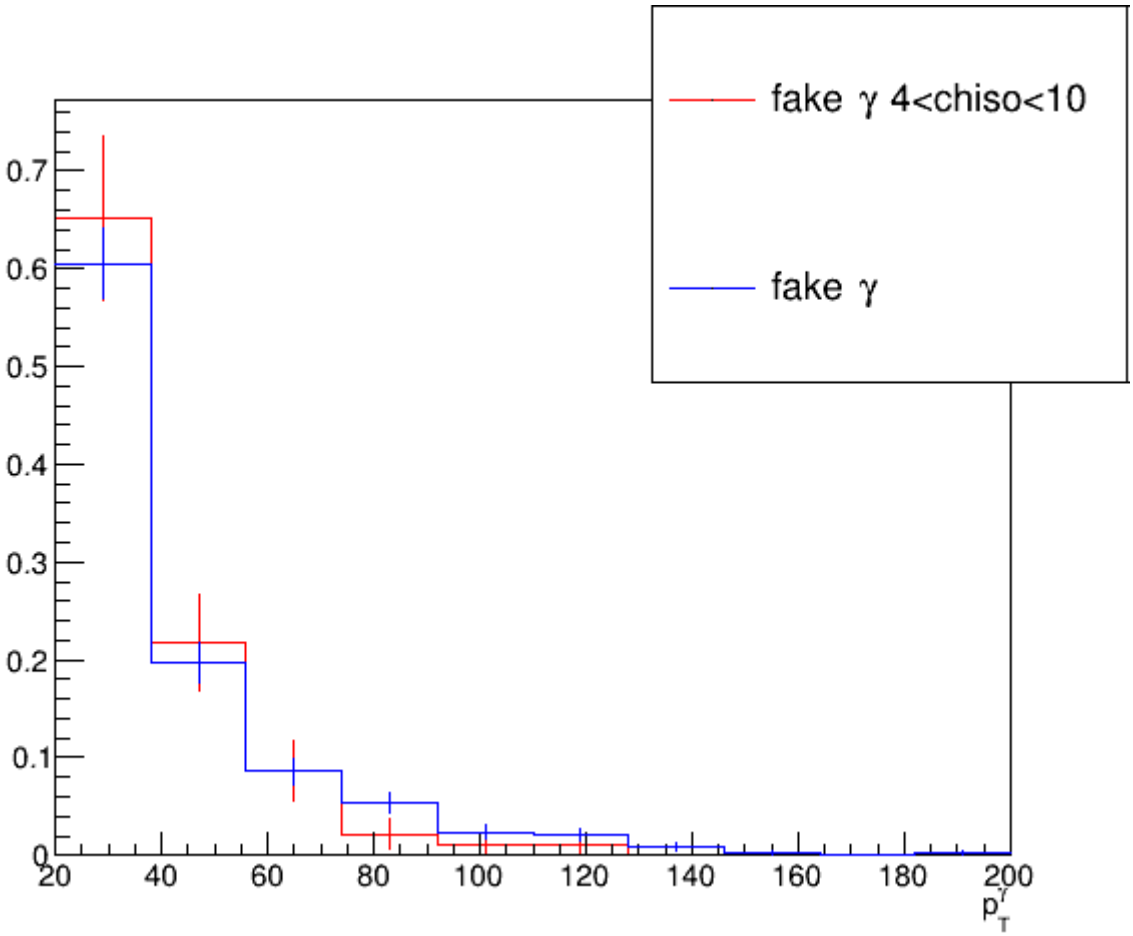
Out[145…

```
468
```

In [146…

```
c1=ROOT.TCanvas('c1','',600,500)
leg=ROOT.TLegend(0.6,0.6,1.0,1.0)
c1.Draw()
hist1.SetLineColor(2)
hist2.SetLineColor(4)
hist1.GetXaxis().SetTitle('p_{T}^{#gamma}')
leg.AddEntry(hist1,'fake #gamma 4<chiso<10')
leg.AddEntry(hist2,'fake #gamma')
hist1.DrawNormalized('HIST E')
hist2.DrawNormalized('HIST SAME E')
leg.Draw()
```

```
Warning in <TCanvas::Constructor>: Deleting canvas with same name: c1
```



Exercise3

In [10]:
```
fdir='/data/pubfs/pku_visitor/public_write/fakephoton_hist/'
```

In [68]:
```
fake = ROOT.TFile.Open(fdir+'Fake_template-DMuon18.root')
```

In [69]:
```
true = ROOT.TFile.Open(fdir+'True_template-ZA18.root')
```

In [70]:
```
data = ROOT.TFile.Open(fdir+'Data_template-DMuon18.root')
```

In [71]:
```
nBins=9
sieie_bin=3
bins=[]
for i in range(0,nBins+1):
     bins.append(0.00515+0.0025*2/3*i)
```

In [201…
```
import numpy as np
def fit(lowpt,highpt):
    hdata_= data.Get("h3_pt{}_{}".format(lowpt,highpt))
    hfake_= fake.Get("h2_pt{}_{}".format(lowpt,highpt))
    htrue_= true.Get("h1_pt{}_{}".format(lowpt,highpt))

    hdata=hdata_.Rebin(nBins,'hdata',np.array(bins))
    hfake=hfake_.Rebin(nBins,'hfake',np.array(bins))
    htrue=htrue_.Rebin(nBins,'htrue',np.array(bins))
```

```
    nData=hdata.GetSum()
    sieie=ROOT.RooRealVar("sieie", "sieie", 0.00515, 0.02015)
    data_hist=ROOT.RooDataHist('datahist','datahist',sieie,hdata)
    true_hist=ROOT.RooDataHist('truehist','truehist',sieie,htrue)
    fake_hist=ROOT.RooDataHist('fakehist','fakehist',sieie,hfake)

    true_pdf=ROOT.RooHistPdf("truepdf", "truepdf", sieie, true_hist)
    fake_pdf=ROOT.RooHistPdf("fakepdf", "fakepdf", sieie, fake_hist)

    nFake=ROOT.RooRealVar("fake number", "fake number",0, nData)
    nTrue=ROOT.RooRealVar("true number", "true number",0, nData)

    etrue_pdf=ROOT.RooExtendPdf("ntrue", "ntrue", true_pdf, nTrue)
    efake_pdf=ROOT.RooExtendPdf("nfake", "nfake", fake_pdf, nFake);

    fullpdf=ROOT.RooAddPdf("full_pdf", "true_plus_fake", ROOT.RooArgList(etru

    fullpdf.fitTo(data_hist,ROOT.RooFit.SumW2Error(ROOT.kFALSE), ROOT.RooFit.

    xframe=sieie.frame(ROOT.RooFit.Title(str(lowpt)+'<pt<'+str(highpt)),ROOT.
    data_hist.plotOn(xframe)
    fullpdf.plotOn(xframe, ROOT.RooFit.Name("sum"), ROOT.RooFit.LineColor(ROO
    fullpdf.plotOn(xframe, ROOT.RooFit.Components("ntrue"), ROOT.RooFit.Name(
    fullpdf.plotOn(xframe, ROOT.RooFit.Components("nfake"), ROOT.RooFit.Name(

    sieie.setRange('window',0.00515,0.01015)
    fracFake=efake_pdf.createIntegral(sieie,sieie,"window")
    nFake_fit = nFake.getVal()
    nFake_inwindow = nFake_fit*fracFake.getVal()
    nDataInWindow = hdata.Integral(1,sieie_bin)
    fakerate = nFake_inwindow/nDataInWindow
    strFR='FR= %0.3f' %(fakerate)

    chi2=ROOT.RooChi2Var("chi2", "chi2", fullpdf, data_hist)
    chi2ToNDF = chi2.getVal() / (nBins - 2);
    strChi2 = '#chi^{2}/ndf=%0.2f' %(chi2ToNDF)

    strLatex=strFR+', '+strChi2

    hdata.SetLineColor(ROOT.kRed)
    hfake.SetLineColor(ROOT.kBlue)
    htrue.SetLineColor(ROOT.kGreen)
    leg=ROOT.TLegend(0.55,0.6,0.9,0.9)
    leg.AddEntry(hdata,'Fit results','L')
    leg.AddEntry(htrue,'True photon','L')
    leg.AddEntry(hfake,'Fake photon','L')
    textFR=ROOT.TLatex(0.5,0.5,strLatex)
    c1=ROOT.TCanvas("c1", "c1", 500, 400)
    c1.Draw()
    xframe.Draw()
    leg.Draw()
    textFR.SetTextSize(0.05)
    textFR.SetNDC()
    textFR.Draw()

    print(strLatex)
    c1.Print('./pt'+str(lowpt)+'_'+str(highpt)+'.pdf')
```

In [204…

```
fit(20,25)
```

```
FR= 0.436, #chi^{2}/ndf=19.20
```

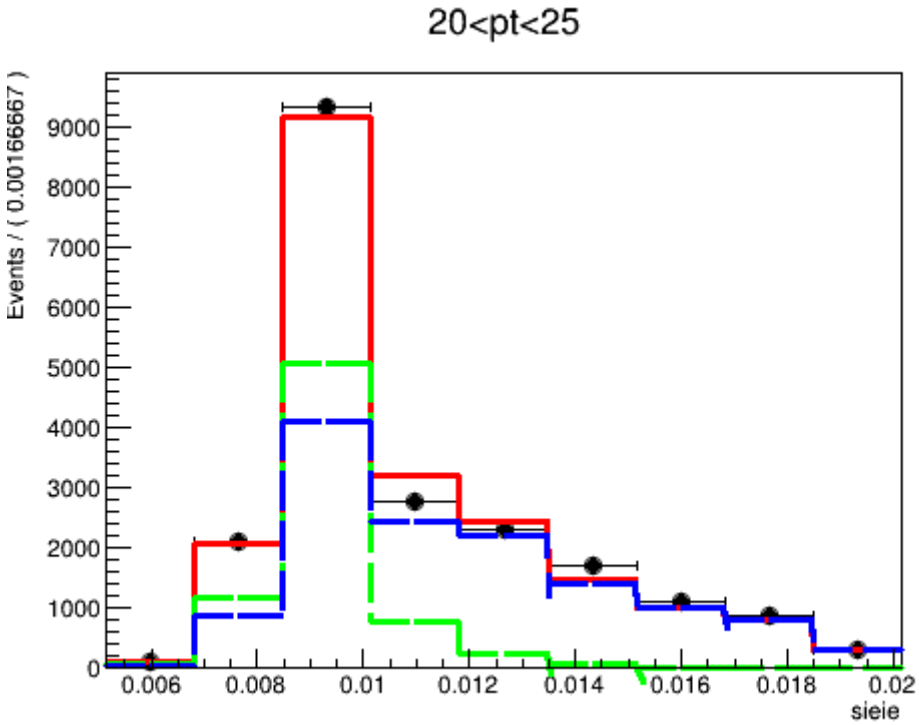
Out[204…

```
<cppyy.gbl.TCanvas object at 0x55a61277da80>
```

```
**********
**  262 **SET PRINT           1
**********
**********
**  263 **SET NOGRAD
**********
PARAMETER DEFINITIONS:
   NO.   NAME         VALUE      STEP SIZE      LIMITS
    1 fake number   1.04530e+04  2.09060e+03    0.00000e+00  2.09060e+04
    2 true number   1.04530e+04  2.09060e+03    0.00000e+00  2.09060e+04
**********
**  264 **SET ERR         0.5
**********
**********
**  265 **SET PRINT           1
**********
**********
**  266 **SET STR           1
**********
NOW USING STRATEGY  1: TRY TO BALANCE SPEED AGAINST RELIABILITY
**********
**  267 **MIGRAD        1000           1
**********
FIRST CALL TO USER FUNCTION AT NEW START POINT, WITH IFLAG=4.
START MIGRAD MINIMIZATION.  STRATEGY  1.  CONVERGENCE WHEN EDM .LT. 1.00e-03
FCN=-281431 FROM MIGRAD    STATUS=INITIATE        8 CALLS           9 TOTAL
                     EDM= unknown      STRATEGY= 1      NO ERROR MATRIX
 EXT PARAMETER               CURRENT GUESS       STEP         FIRST
 NO.   NAME      VALUE            ERROR          SIZE      DERIVATIVE
  1  fake number   1.04530e+04   2.09060e+03   2.01358e-01  -6.65599e+02
  2  true number   1.04530e+04   2.09060e+03   2.01358e-01   9.12418e+02
                               ERR DEF= 0.5
MIGRAD MINIMIZATION HAS CONVERGED.
MIGRAD WILL VERIFY CONVERGENCE AND ERROR MATRIX.
COVARIANCE MATRIX CALCULATED SUCCESSFULLY
FCN=-281646 FROM MIGRAD    STATUS=CONVERGED      45 CALLS          46 TOTAL
                     EDM=3.33185e-06    STRATEGY= 1      ERROR MATRIX ACCURATE
 EXT PARAMETER                                       STEP         FIRST
 NO.   NAME      VALUE            ERROR          SIZE      DERIVATIVE
  1  fake number   1.32188e+04   1.70157e+02   4.91447e-03  -1.27803e-01
  2  true number   7.43996e+03   1.52344e+02   4.43231e-03  -1.27194e-01
                               ERR DEF= 0.5
EXTERNAL ERROR MATRIX.    NDIM=  25    NPAR=  2    ERR DEF=0.5
 2.896e+04 -1.574e+04
-1.574e+04  2.321e+04
PARAMETER  CORRELATION COEFFICIENTS
      NO.  GLOBAL      1      2
       1  0.60701   1.000 -0.607
       2  0.60701  -0.607  1.000
**********
**  268 **SET ERR         0.5
**********
**********
**  269 **SET PRINT           1
**********
**********
**  270 **HESSE        1000
**********
COVARIANCE MATRIX CALCULATED SUCCESSFULLY
FCN=-281646 FROM HESSE     STATUS=OK             10 CALLS          56 TOTAL
                     EDM=3.3237e-06    STRATEGY= 1      ERROR MATRIX ACCURATE
 EXT PARAMETER                                   INTERNAL      INTERNAL
 NO.   NAME      VALUE            ERROR       STEP SIZE       VALUE
  1  fake number   1.32188e+04   1.70619e+02   1.96579e-04   2.67780e-01
```

```
   2  true number   7.43996e+03   1.52757e+02   1.77293e-04  -2.92395e-01
                               ERR DEF= 0.5
 EXTERNAL ERROR MATRIX.    NDIM=  25    NPAR=  2    ERR DEF=0.5
  2.911e+04 -1.590e+04
 -1.590e+04  2.334e+04
 PARAMETER  CORRELATION COEFFICIENTS
       NO.  GLOBAL      1      2
        1  0.60982   1.000 -0.610
        2  0.60982  -0.610  1.000
```

```
Warning in <TH1D::Rebin>: Bin edge 2 of rebinned histogram does not match any bin edges of the old histogram. Result can be inconsistent
Warning in <TH1D::Rebin>: Bin edge 3 of rebinned histogram does not match any bin edges of the old histogram. Result can be inconsistent
Warning in <TH1D::Rebin>: Bin edge 5 of rebinned histogram does not match any bin edges of the old histogram. Result can be inconsistent
Warning in <TH1D::Rebin>: Bin edge 6 of rebinned histogram does not match any bin edges of the old histogram. Result can be inconsistent
Warning in <TH1D::Rebin>: Bin edge 8 of rebinned histogram does not match any bin edges of the old histogram. Result can be inconsistent
Warning in <TH1D::Rebin>: Bin edge 9 of rebinned histogram does not match any bin edges of the old histogram. Result can be inconsistent
Warning in <TH1D::Rebin>: Bin edge 2 of rebinned histogram does not match any bin edges of the old histogram. Result can be inconsistent
Warning in <TH1D::Rebin>: Bin edge 3 of rebinned histogram does not match any bin edges of the old histogram. Result can be inconsistent
Warning in <TH1D::Rebin>: Bin edge 5 of rebinned histogram does not match any bin edges of the old histogram. Result can be inconsistent
Warning in <TH1D::Rebin>: Bin edge 6 of rebinned histogram does not match any bin edges of the old histogram. Result can be inconsistent
Warning in <TH1D::Rebin>: Bin edge 8 of rebinned histogram does not match any bin edges of the old histogram. Result can be inconsistent
Warning in <TH1D::Rebin>: Bin edge 9 of rebinned histogram does not match any bin edges of the old histogram. Result can be inconsistent
Warning in <TH1D::Rebin>: Bin edge 2 of rebinned histogram does not match any bin edges of the old histogram. Result can be inconsistent
Warning in <TH1D::Rebin>: Bin edge 3 of rebinned histogram does not match any bin edges of the old histogram. Result can be inconsistent
Warning in <TH1D::Rebin>: Bin edge 5 of rebinned histogram does not match any bin edges of the old histogram. Result can be inconsistent
Warning in <TH1D::Rebin>: Bin edge 6 of rebinned histogram does not match any bin edges of the old histogram. Result can be inconsistent
Warning in <TH1D::Rebin>: Bin edge 8 of rebinned histogram does not match any bin edges of the old histogram. Result can be inconsistent
Warning in <TH1D::Rebin>: Bin edge 9 of rebinned histogram does not match any bin edges of the old histogram. Result can be inconsistent
Warning in <TCanvas::Constructor>: Deleting canvas with same name: c1
Info in <TCanvas::Print>: pdf file ./pt20_25.pdf has been created
```



In [205…

```
fit(25,30)
```

```
FR= 0.376, #chi^{2}/ndf=8.99
<cppyy.gbl.TCanvas object at 0x55a612785b20>
```

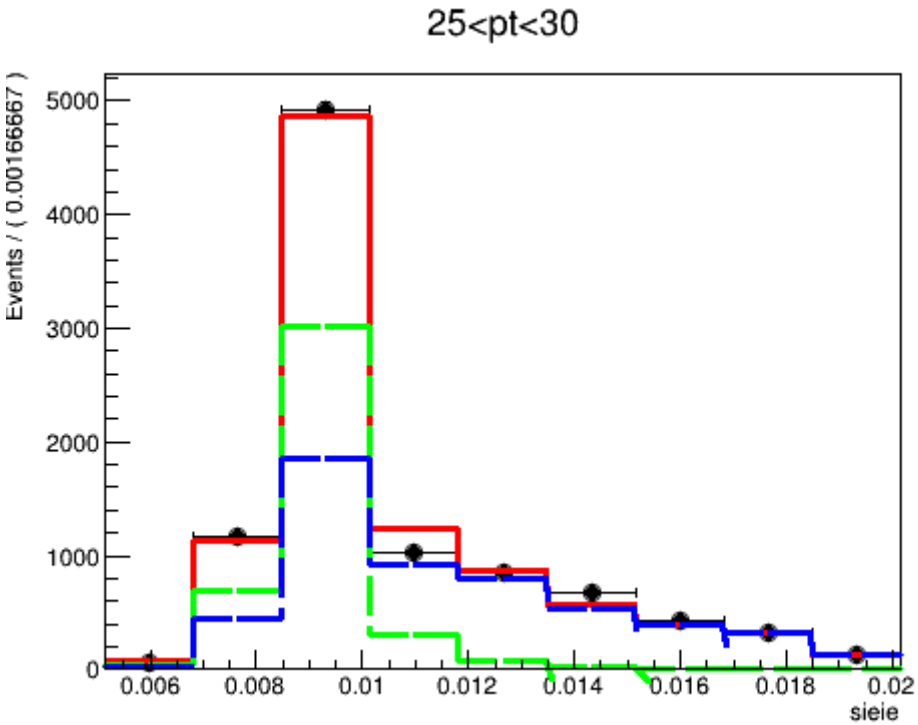
Out[205…

```
**********
**   271 **SET PRINT           1
**********
**********
**   272 **SET NOGRAD
**********
PARAMETER DEFINITIONS:
   NO.   NAME         VALUE      STEP SIZE      LIMITS
    1 fake number   4.85250e+03  9.70500e+02    0.00000e+00  9.70500e+03
    2 true number   4.85250e+03  9.70500e+02    0.00000e+00  9.70500e+03
**********
**   273 **SET ERR         0.5
**********
**********
**   274 **SET PRINT           1
**********
**********
**   275 **SET STR           1
**********
NOW USING STRATEGY  1: TRY TO BALANCE SPEED AGAINST RELIABILITY
**********
**   276 **MIGRAD        1000           1
**********
FIRST CALL TO USER FUNCTION AT NEW START POINT, WITH IFLAG=4.
START MIGRAD MINIMIZATION.  STRATEGY  1.  CONVERGENCE WHEN EDM .LT. 1.00e-03
FCN=-124515 FROM MIGRAD    STATUS=INITIATE        8 CALLS           9 TOTAL
                     EDM= unknown      STRATEGY= 1      NO ERROR MATRIX
 EXT PARAMETER               CURRENT GUESS       STEP         FIRST
 NO.   NAME      VALUE            ERROR          SIZE      DERIVATIVE
  1  fake number   4.85250e+03   9.70500e+02   2.01358e-01  -1.19518e+02
  2  true number   4.85250e+03   9.70500e+02   2.01358e-01   2.28481e+02
                               ERR DEF= 0.5
MIGRAD MINIMIZATION HAS CONVERGED.
MIGRAD WILL VERIFY CONVERGENCE AND ERROR MATRIX.
```

```
COVARIANCE MATRIX CALCULATED SUCCESSFULLY
FCN=-124538 FROM MIGRAD    STATUS=CONVERGED      39 CALLS          40 TOTAL
                     EDM=1.2945e-05    STRATEGY= 1      ERROR MATRIX ACCURATE
 EXT PARAMETER                                   STEP         FIRST
 NO.   NAME      VALUE            ERROR          SIZE      DERIVATIVE
  1  fake number   5.42066e+03   1.09941e+02   4.51711e-03  -1.58358e-01
  2  true number   4.17516e+03   1.04156e+02   4.29948e-03  -1.20237e-03
                               ERR DEF= 0.5
EXTERNAL ERROR MATRIX.    NDIM=  25    NPAR=  2    ERR DEF=0.5
 1.209e+04 -6.664e+03
-6.664e+03  1.085e+04
PARAMETER  CORRELATION COEFFICIENTS
      NO.  GLOBAL      1      2
       1  0.58186   1.000 -0.582
       2  0.58186  -0.582  1.000
**********
**  277 **SET ERR         0.5
**********
**********
**  278 **SET PRINT           1
**********
**********
**  279 **HESSE        1000
**********
COVARIANCE MATRIX CALCULATED SUCCESSFULLY
FCN=-124538 FROM HESSE     STATUS=OK             10 CALLS          50 TOTAL
                     EDM=1.29991e-05    STRATEGY= 1      ERROR MATRIX ACCURATE
 EXT PARAMETER                                INTERNAL      INTERNAL
 NO.   NAME      VALUE            ERROR       STEP SIZE       VALUE
  1  fake number   5.42066e+03   1.10185e+02   1.80685e-04   1.17356e-01
  2  true number   4.17516e+03   1.04387e+02   1.71979e-04  -1.40044e-01
                               ERR DEF= 0.5
EXTERNAL ERROR MATRIX.    NDIM=  25    NPAR=  2    ERR DEF=0.5
 1.214e+04 -6.723e+03
-6.723e+03  1.090e+04
PARAMETER  CORRELATION COEFFICIENTS
      NO.  GLOBAL      1      2
       1  0.58437   1.000 -0.584
       2  0.58437  -0.584  1.000
```

```
Warning in <TH1D::Rebin>: Bin edge 2 of rebinned histogram does not match any
bin edges of the old histogram. Result can be inconsistent
Warning in <TH1D::Rebin>: Bin edge 3 of rebinned histogram does not match any
bin edges of the old histogram. Result can be inconsistent
Warning in <TH1D::Rebin>: Bin edge 5 of rebinned histogram does not match any
bin edges of the old histogram. Result can be inconsistent
Warning in <TH1D::Rebin>: Bin edge 6 of rebinned histogram does not match any
bin edges of the old histogram. Result can be inconsistent
Warning in <TH1D::Rebin>: Bin edge 8 of rebinned histogram does not match any
bin edges of the old histogram. Result can be inconsistent
Warning in <TH1D::Rebin>: Bin edge 9 of rebinned histogram does not match any
bin edges of the old histogram. Result can be inconsistent
Warning in <TH1D::Rebin>: Bin edge 2 of rebinned histogram does not match any
bin edges of the old histogram. Result can be inconsistent
Warning in <TH1D::Rebin>: Bin edge 3 of rebinned histogram does not match any
bin edges of the old histogram. Result can be inconsistent
Warning in <TH1D::Rebin>: Bin edge 5 of rebinned histogram does not match any
bin edges of the old histogram. Result can be inconsistent
Warning in <TH1D::Rebin>: Bin edge 6 of rebinned histogram does not match any
bin edges of the old histogram. Result can be inconsistent
Warning in <TH1D::Rebin>: Bin edge 8 of rebinned histogram does not match any
bin edges of the old histogram. Result can be inconsistent
Warning in <TH1D::Rebin>: Bin edge 9 of rebinned histogram does not match any
bin edges of the old histogram. Result can be inconsistent
Warning in <TH1D::Rebin>: Bin edge 2 of rebinned histogram does not match any
```

```
bin edges of the old histogram. Result can be inconsistent
Warning in <TH1D::Rebin>: Bin edge 3 of rebinned histogram does not match any
bin edges of the old histogram. Result can be inconsistent
Warning in <TH1D::Rebin>: Bin edge 5 of rebinned histogram does not match any
bin edges of the old histogram. Result can be inconsistent
Warning in <TH1D::Rebin>: Bin edge 6 of rebinned histogram does not match any
bin edges of the old histogram. Result can be inconsistent
Warning in <TH1D::Rebin>: Bin edge 8 of rebinned histogram does not match any
bin edges of the old histogram. Result can be inconsistent
Warning in <TH1D::Rebin>: Bin edge 9 of rebinned histogram does not match any
bin edges of the old histogram. Result can be inconsistent
Warning in <TCanvas::Constructor>: Deleting canvas with same name: c1
Info in <TCanvas::Print>: pdf file ./pt25_30.pdf has been created
```



Exercise 4

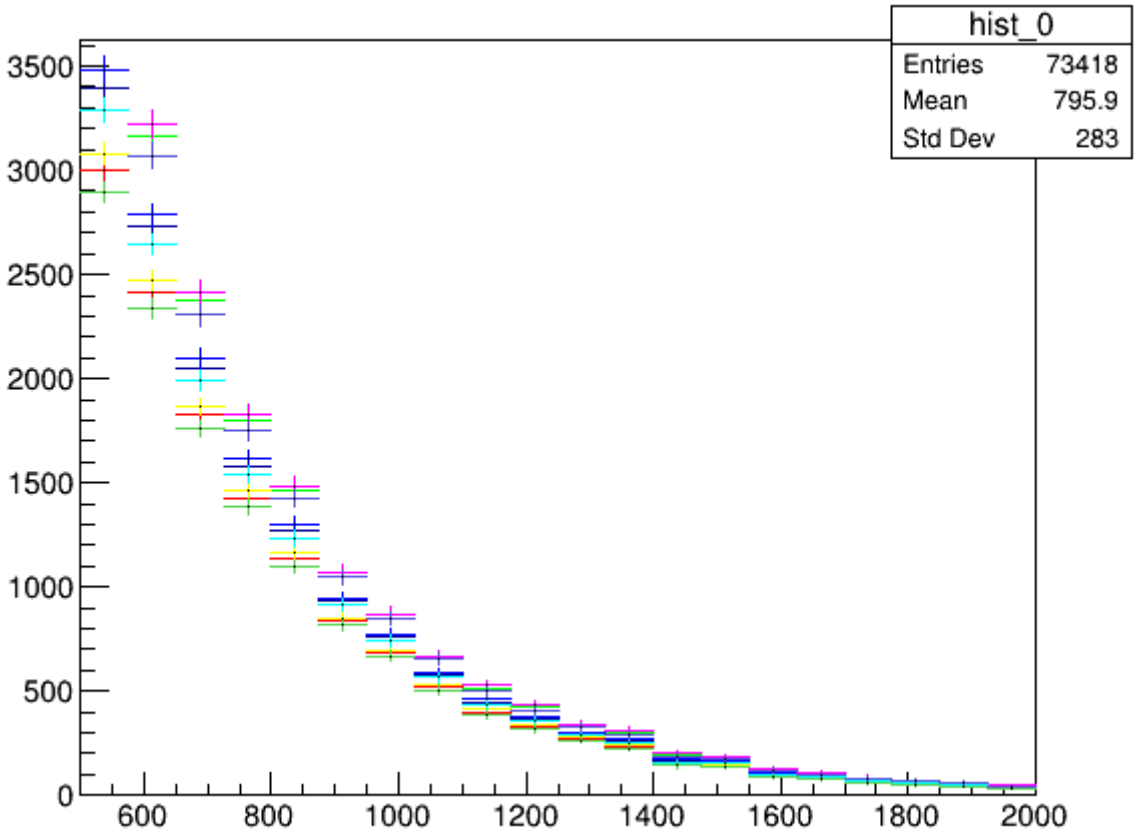
In [153…

```
hist=[]
for i in range(0,9):
    h1=ROOT.TH1D('hist_{}'.format(i),'',20,500,2000)

    tree2.Draw('Mjj>>hist_{}'.format(i),'(Mjj>500)*pweight['+str(i)+']','HIST
    hist.append(h1)
```

In [158…

```
c1=ROOT.TCanvas('c1','',600,500)
c1.Draw()
hist[0].Draw()
for i in range(1,9):
    hist[i].SetLineColor(i+1)
    hist[i].Draw('same')
```

```
Warning in <TCanvas::Constructor>: Deleting canvas with same name: c1
```



The uncertainty in every bin can be calculated.