

Çözümleme Örneği

Bora Akgün / Rice Üniversitesi

HPFBU okulu - Şubat 2014

Nobel Fizik Ödülü - 2013

VOLUME 13, NUMBER 9

PHYSICAL REVIEW LETTERS

31 AUGUST 1964

BROKEN SYMMETRY AND THE MASS OF GAUGE VECTOR MESONS*

F. Englert and R. Brout

Faculté des Sciences, Université Libre de Bruxelles, Bruxelles, Belgium
(Received 26 June 1964)



François Englert

VOLUME 13, NUMBER 16

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BROKEN SYMMETRIES AND THE MASSES OF GAUGE BOSONS

Peter W. Higgs

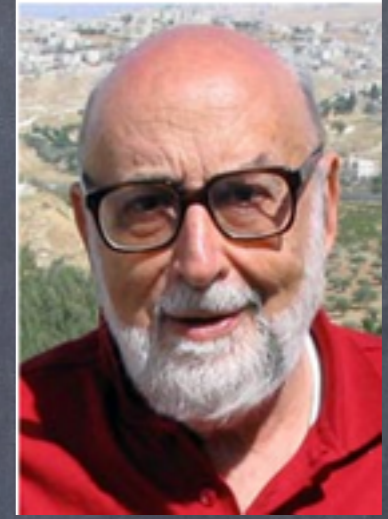
Tait Institute of Mathematical Physics, University of Edinburgh, Edinburgh, Scotland
(Received 31 August 1964)



Peter W. Higgs

Nobel Fizik Ödülü - 2013

- "for the theoretical discovery of a mechanism that contributes to our understanding of the origin of mass of subatomic particles, and which recently was confirmed through the discovery of the predicted fundamental particle, by the ATLAS and CMS experiments at CERN's Large Hadron Collider"
- "atomaltı parçacıkların kütlelerinin kökenini anlamamıza katkı yapan bir kuramsal mekanizmanın keşfi ve CERN'nin LHC deneylerinden ATLAS ve CMS'in doğruladığı temel parçacığı öngörmelerinden dolayı"



François Englert



Peter W. Higgs

Nobel Fizik Ödülü - 2013

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EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH (CERN)


 CMS-HIG-12-028


 CERN-PH-EP/2012-220
2013/01/29

Observation of a new boson at a mass of 125 GeV with the CMS experiment at the LHC

The CMS Collaboration

EUROPEAN ORGANISATION FOR NUCLEAR RESEARCH (CERN)

 ATLAS

 CERN

CERN-PH-EP-2012-218
Accepted by: Physics Letters B

Observation of a New Particle in the Search for the Standard Model Higgs Boson with the ATLAS Detector at the LHC

The ATLAS Collaboration



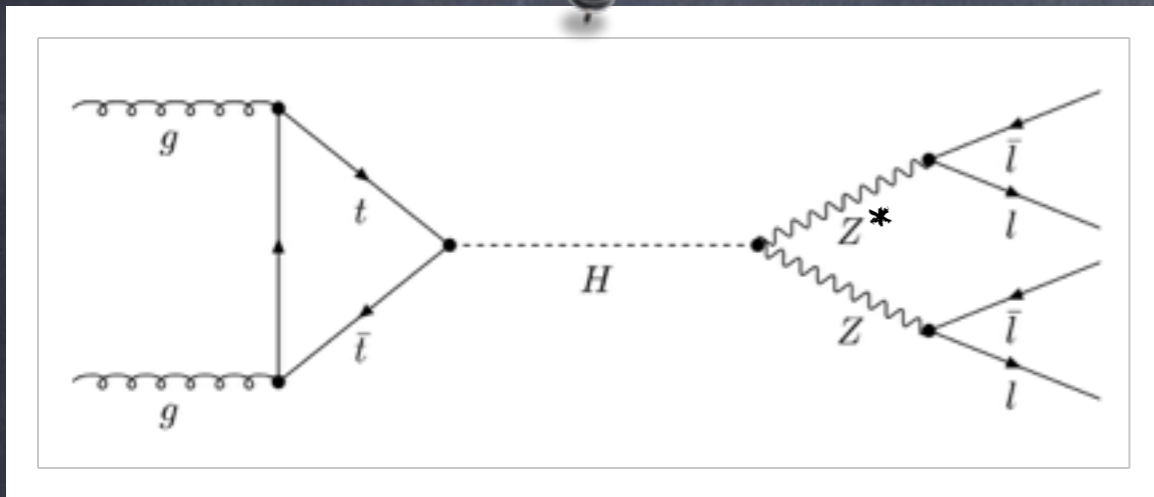
Peter W. Higgs

Bir Çözümleme Örneği olarak Higgs Bozonu

- Higgs Bozonu ATLAS ve CMS dedektörleri tarafından keşfedildi, $m_H \sim 126 \text{ GeV}$
- Biz burada öğrendiklerimizle Higgs MC olaylarını inceleyebilir miyiz?
 - Nasıl bir bozunma?
 - Sinyal ve ardalanan MC olay üretimi
 - Benzetme
 - Çözümleme, değerlendirme

Nasıl bir bozunma?

Bozunma ürünlerinden başlayıp keşif yapabilir miyiz?



sinyal
 $pp \rightarrow H \rightarrow ZZ^* \rightarrow 4l$

* ne anlama geliyor?

ardalan
 $pp \rightarrow 4l$

Hedef ve Aletler

sinyal
 $pp \rightarrow H \rightarrow ZZ^* \rightarrow 4L$

ardalan
 $pp \rightarrow 4L$

- CompHep, MadGraph
- Olay üretimi
- Pythia
- Parton yağmuru, hadronlaşma
- Delphes/Geant
- Dedektör simülasyonu
- Root
- Veri incelenmesi

Sinyal ve Ardalan (.root) dosyaları

- Sinyal ve ardalan (.root) dosyaları ayrı ayrı üretildi
- Ancak gerçek bir dedektör verisi incelerken sinyal ve ardalan ayrımı yok
 - Bu yüzden biz de iki dosyayı birleştirip inceleyelim
 - Sonra sadece sinyal dosyasına bakarız

```
[fizikci@hpfbu tokat]$ hadd all.root sig.root bg.root
hadd Target file: all.root
hadd Source file 1: sig.root
Warning in <TClass::TClass>: no dictionary for class LHEFEvent is available
Warning in <TClass::TClass>: no dictionary for class Event is available
Warning in <TClass::TClass>: no dictionary for class GenParticle is available
Warning in <TClass::TClass>: no dictionary for class SortableObject is available
Warning in <TClass::TClass>: no dictionary for class Track is available
Warning in <TClass::TClass>: no dictionary for class Tower is available
Warning in <TClass::TClass>: no dictionary for class Muon is available
Warning in <TClass::TClass>: no dictionary for class Jet is available
Warning in <TClass::TClass>: no dictionary for class Electron is available
Warning in <TClass::TClass>: no dictionary for class Photon is available
Warning in <TClass::TClass>: no dictionary for class MissingET is available
Warning in <TClass::TClass>: no dictionary for class ScalarHT is available
hadd Source file 2: bg.root
hadd Target path: all.root:/
```

```
[fizikci@hpfbu tokat]$ ls -lrt
total 250900
-rw-r--r-- 1 fizikci users 16414487 Nov 14 17:23 sig.root
-rw-r--r-- 1 fizikci users 112042557 Nov 14 17:24 bg.root
-rw-r--r-- 1 fizikci users 128447487 Nov 14 17:24 all.root
```


Çözümleme - Root ile ilk bakış

- Dosyayı yükleyelim, içeriğine bakalım

- `root -l all.root`

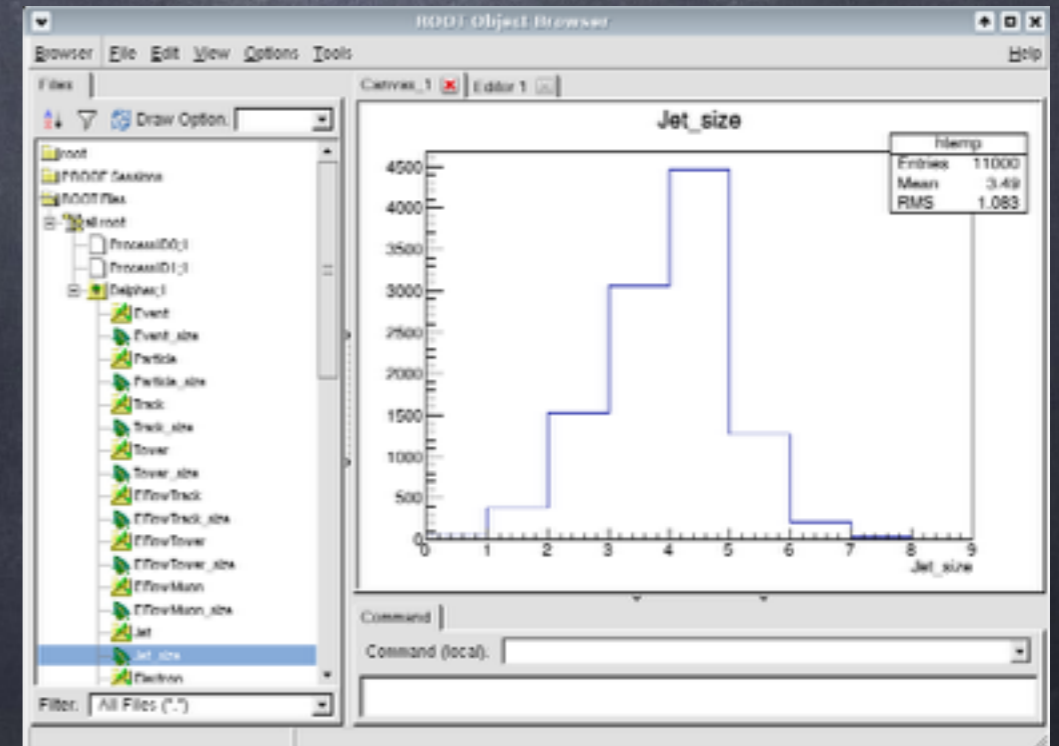
```
[fizikci@hpfbu tokat]$ root -l all.root
root [0]
Attaching file all.root as _file0...
```

- `new TBrowser`

```
root [1] new TBrowser
(class TBrowser*)0x86a1818
```

- Delphes ağacının içinde neler var?

- Dallar
- Yapraklar



Çözümleme - dosya (.C , .h) üretme

- Root ile bir çözümleme iskeleti yapalım

- Komut satırına yazalım

```
root [1] Delphes->MakeClass("hpfbu_all")
Info in <TTreePlayer::MakeClass>: Files: hpfbu_all.h and hpfbu_all.C generated from TTree: Delphes
(Int_t)0
```

- Delphes->MakeClass("hpfbu_all")

- 2 yeni dosya üretilmiş oldu

- hpfbu_all.C ve hpfbu_all.h

- Yeni dosyalara bir göz atalım

- emacs hpfbu_all.C

- less hpfbu_all.h

```
void hpfbu_all::loop()
{
  // In a ROOT session, you can do:
  // root > .L hpfbu_all.C
  // root > hpfbu_all
  // root > t.GetEntry(12); // Fill t data members with entry number 12
  // root > t.Show(); // Show values of entry 12
  // root > t.Show(10); // Read and show values of entry 10
  // root > t.loop(); // Loop on all entries

  // This is the loop skeleton where:
  // jentry is the global entry number in the chain
  // ientry is the entry number in the current Tree
  // Note that the argument to GetEntry must be:
  // jentry for TChain::GetEntry
  // ientry for TTree::GetEntry and TBranch::GetEntry

  // To read only selected branches, insert statements like:
  // METHOD1:
  // fChain->SetBranchStatus("branchname",0); // disable branchname
  // fChain->SetBranchStatus("branchname",1); // activate branchname
  // METHOD2: replace line
  // fChain->GetEntry(jentry); //read all branches
  // by fChain->GetEntry(jentry); //read only this branch
  if (fChain == 0) return;

  Long64_t nentries = fChain->GetEntriesFast();
  Long64_t nbytes = 0, nb = 0;
  for (Long64_t jentry=0; jentry<nentries;jentry++) {
    Long64_t ientry = LoadTree(jentry);
    if (ientry < 0) break;
    nb = fChain->GetEntry(jentry); nbytes += nb;
    // if (Cut(jentry) < 0) continue;
  }
}
```

```
////////////////////////////////////
// This class has been automatically generated on
// Thu Nov 14 17:26:28 2013 by ROOT version 5.34/09
// from TTree Delphes/Analysis tree
// found on file: all.root
////////////////////////////////////

#ifndef hpfbu_all_h
#define hpfbu_all_h

#include <TROOT.h>
#include <TChain.h>
#include <TFile.h>

// Header file for the classes stored in the TTree if any.
#include <TClonesArray.h>
#include <TObject.h>

// Fixed size dimensions of array or collections stored in the TTree if any.
const Int_t kMaxEvent = 1;
const Int_t kMaxParticle = 520;
const Int_t kMaxTrack = 50;
const Int_t kMaxLower = 198;
const Int_t kMaxFlowTrack = 50;
const Int_t kMaxFlowLower = 178;
const Int_t kMaxFlowMuon = 6;
hpfbu_all.h
```


gözümleme - .C dosyasının bölümleri

```
emacs@hpfbu
File Edit Options Buffers Tools C++ Help
// METHOD1:
// fChain->SetBranchStatus("**",0); // disable all branches
// fChain->SetBranchStatus("branchname",1); // activate branchname
// METHOD2: replace line
// fChain->GetEntry(jentry); //read all branches
//by b_branchname->GetEntry(ientry); //read only this branch
if (fChain == 0) return;

Long64_t nentries = fChain->GetEntriesFast();

Long64_t nbytes = 0, nb = 0;
for (Long64_t jentry=0; jentry<nentries;jentry++) {
  Long64_t ientry = LoadTree(jentry);
  if (ientry < 0) break;
  nb = fChain->GetEntry(jentry);  nbytes += nb;
  // if (Cut(ientry) < 0) continue;

} // end of event loop
```

• Tanımlar

• Lorentz Vector

• Histogram

• Pencere

• Olay döngüsü

• Tanımlananları dolduracağız

• Çizimler

• Doldurduklarımızı çizdireceğiz

Çözümleme - 4 muonlu olaylarda Higgs olabilir mi?

- 4 muon değişmez kütlelerine hazırlayalım

```
// Variables
TLorentzVector muon[5];
TLorentzVector M4m;

// Declarations
TH1F *mumult, *jetmult, *elemult, *phmult;
TH1F *mupt, *mue, *muphi, *mucharge;
TH1F *invmass;
```

```
mucharge = new TH1F("mucharge", "Muon charge", 5, -2., 2.);
invmass = new TH1F("invmass", "M_{inv}", 250, 0, 500);
```

```
TCanvas *c3 = new TCanvas("inv_mass_plots", "c3", 150, 10, 450, 450);
c3->Divide(1,1);
```

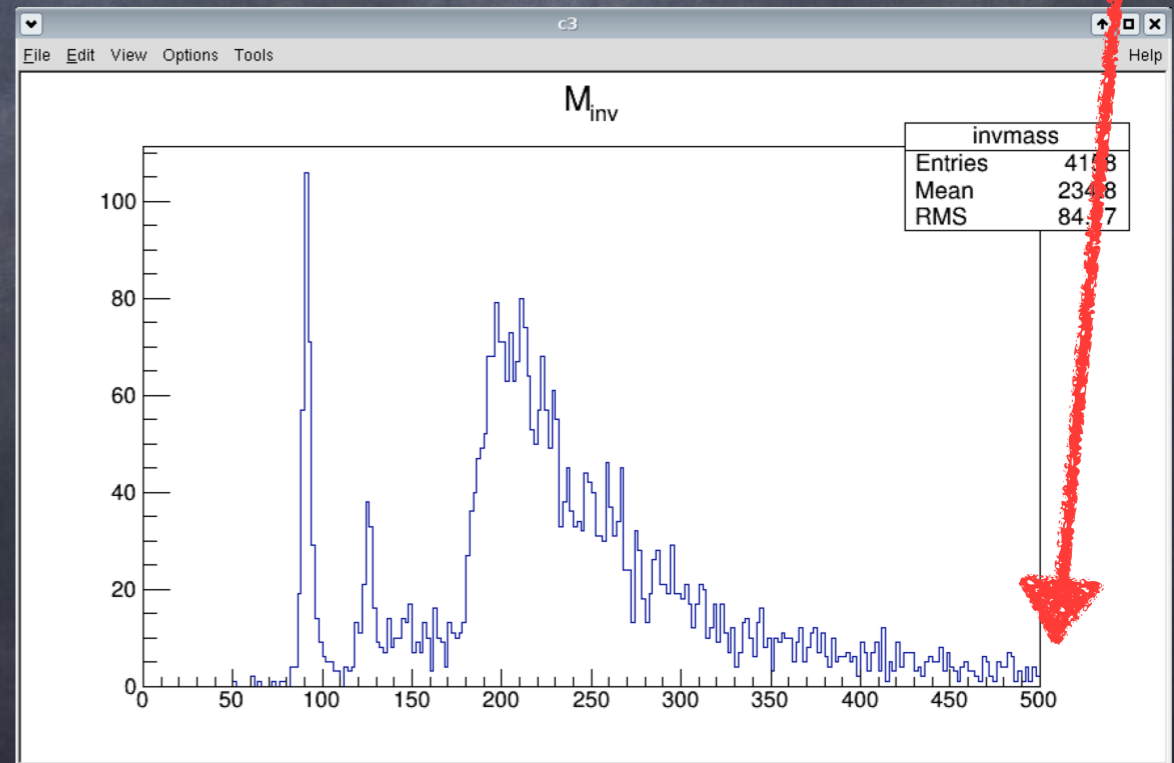
yeterli mi?

yeni

- Hesaplayıp gizdirelim

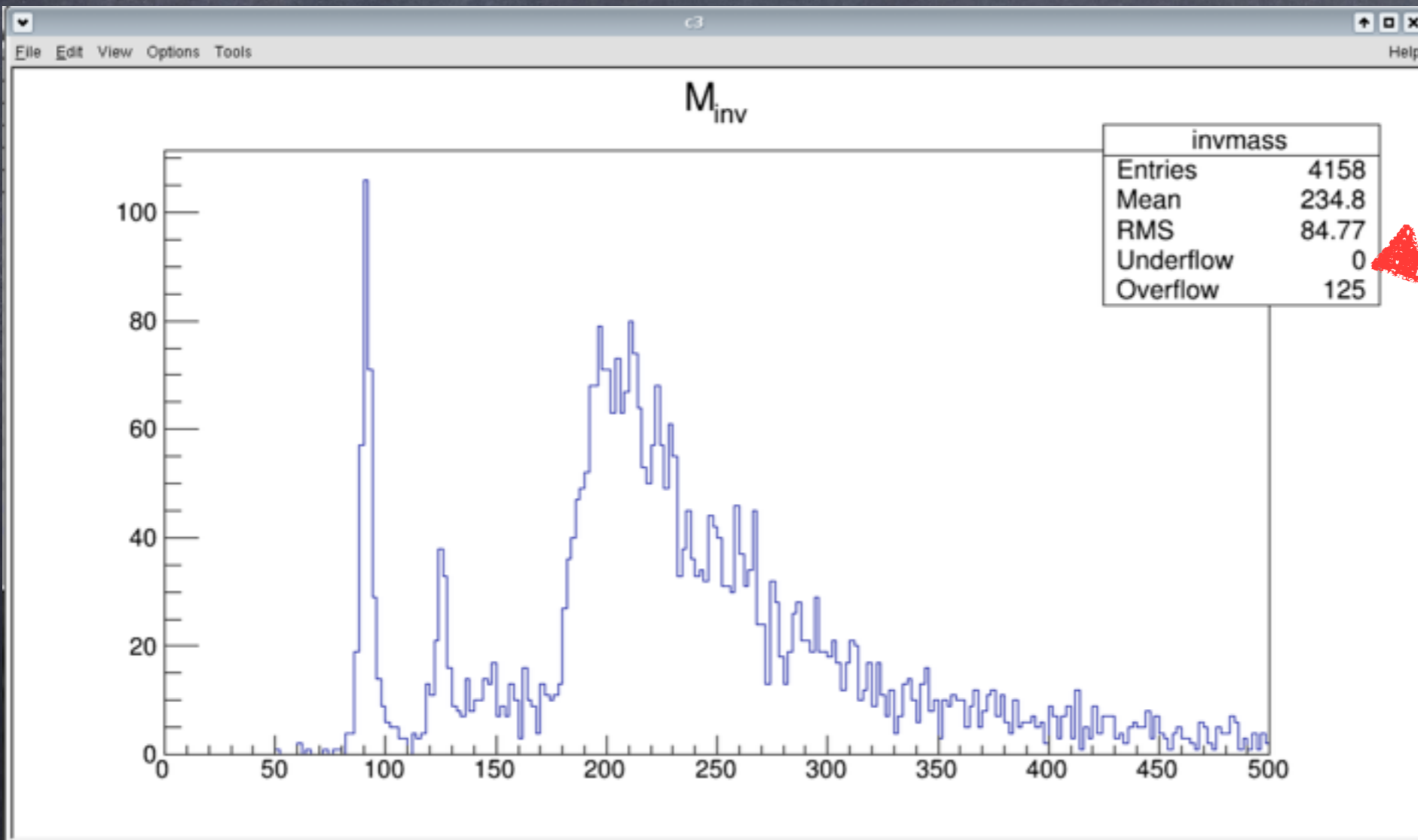
```
if ( Muon_ != 4) continue;
M4m=muon[0]+muon[1]+muon[2]+muon[3];
invmass->Fill(M4m.M());
```

```
c3->cd(1); invmass->Draw();
```



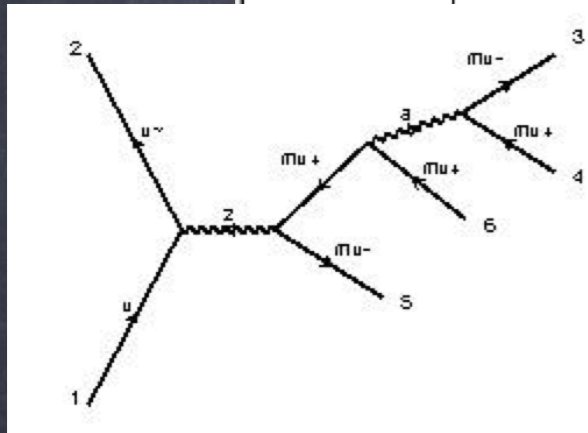
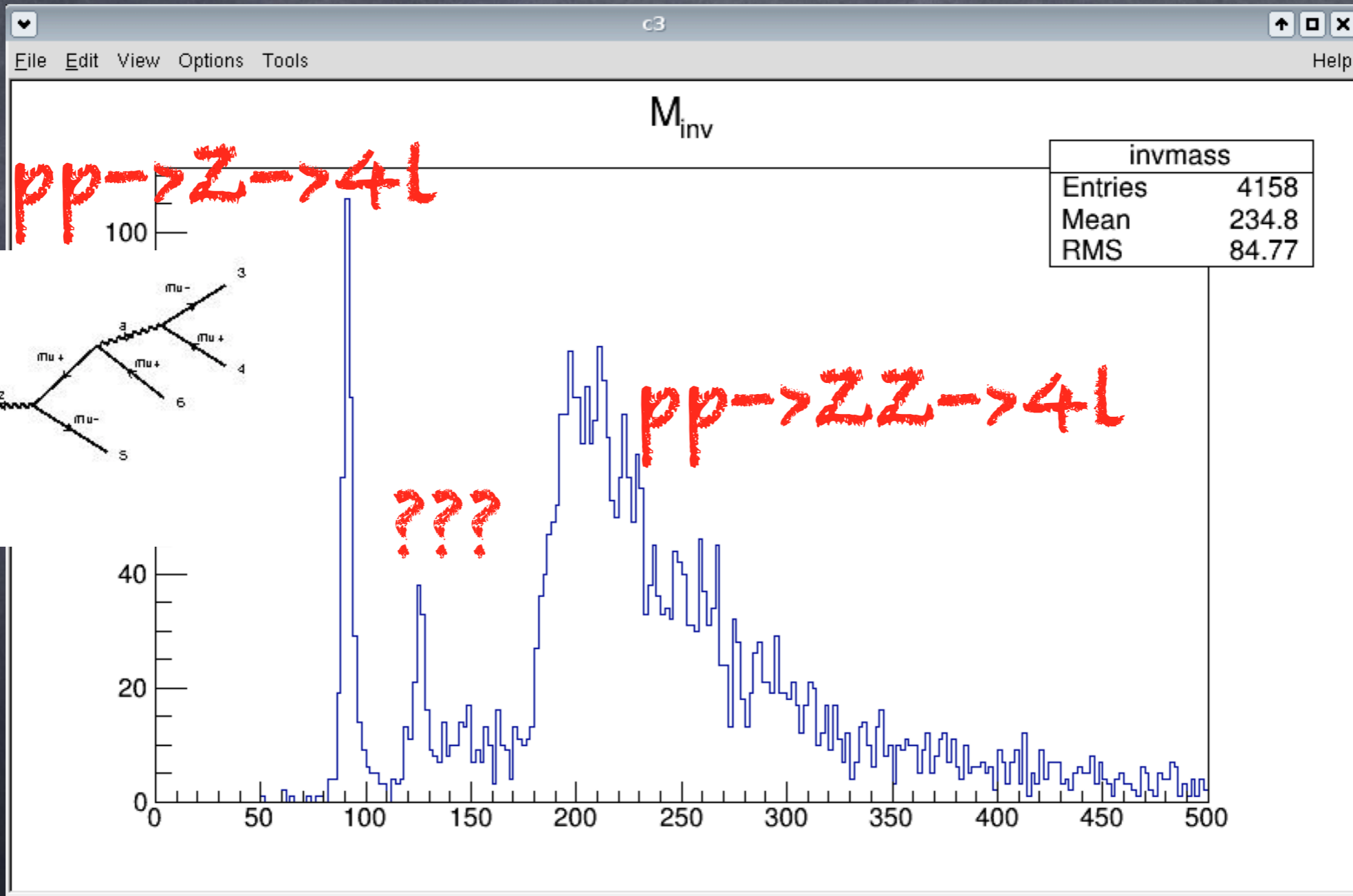
Çözümleme - 4 muonlu
olaylarda Higgs olabilir mi?

```
gStyle->SetOptStat(111111);  
c3->cd(1); invmass->Draw();
```



bu bize ne
söylüyor ?

Çözümleme - 4 muonlu olaylarda Higgs olabilir mi?



Çözümleme - 4 muonlu olaylarda Higgs olabilir mi?

```

if ( (Muon_Charge[0]*Muon_Charge[1] < 0) && (Muon_Charge[2]*Muon_Charge[3] < 0) ) {
  Mz1 = muon[0]+muon[1]; Mz2 = muon[2]+muon[3];
  if ( (Mz1.M() < 110) && (Mz1.M() > 70) && (Mz2.M() < 110) && (Mz2.M() > 70) ) continue;
}
if ( (Muon_Charge[0]*Muon_Charge[2] < 0) && (Muon_Charge[1]*Muon_Charge[3] < 0) ) {
  Mz1 = muon[0]+muon[2]; Mz2 = muon[1]+muon[3];
  if ( (Mz1.M() < 110) && (Mz1.M() > 70) && (Mz2.M() < 110) && (Mz2.M() > 70) ) continue;
}
if ( (Muon_Charge[0]*Muon_Charge[3] < 0) && (Muon_Charge[1]*Muon_Charge[2] < 0) ) {
  Mz1 = muon[0]+muon[3]; Mz2 = muon[1]+muon[2];
  if ( (Mz1.M() < 110) && (Mz1.M() > 70) && (Mz2.M() < 110) && (Mz2.M() > 70) ) continue;
}

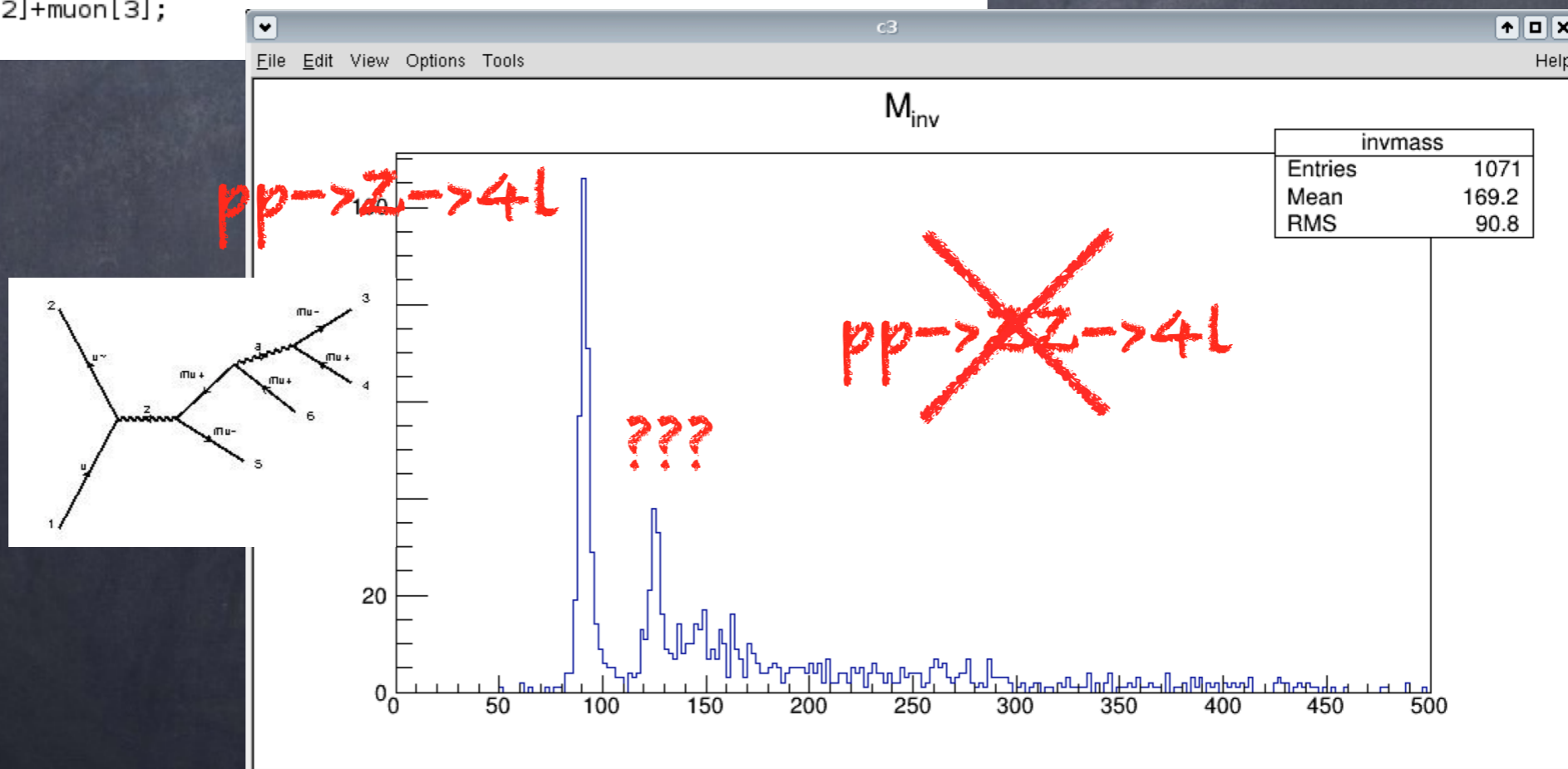
if ( Muon_ != 4) continue;
M4m=muon[0]+muon[1]+muon[2]+muon[3];
invmass->Fill(M4m.M());

```

```

// Variables
TLorentzVector muon[5];
TLorentzVector M4m;
TLorentzVector Mz1; TLorentzVector Mz2;

```

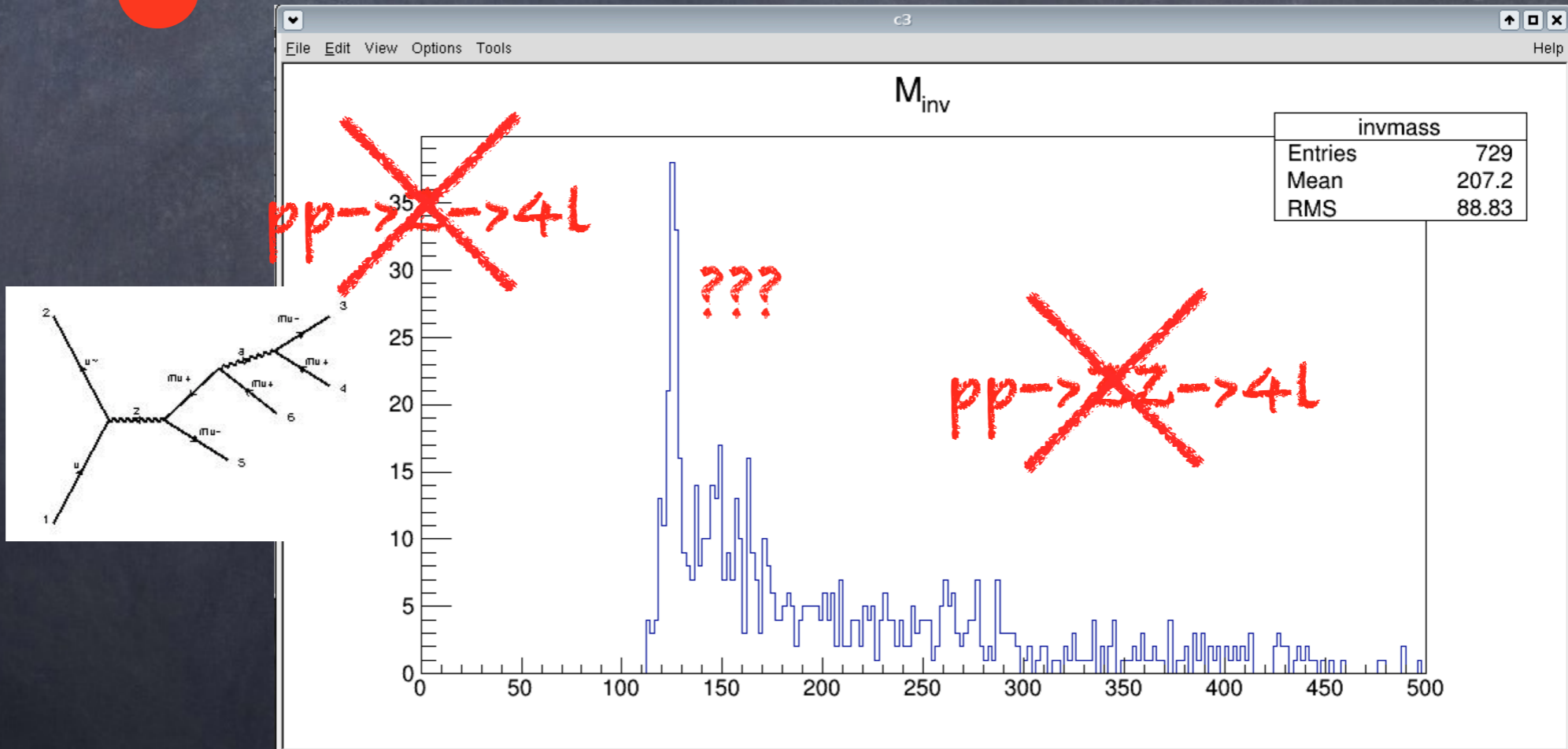


Çözümleme - 4 muonlu olaylarda Higgs olabilir mi?

kullanılmaması gereken yanlış bir kırıpan!!

```
if ( Muon_ != 4) continue;  
M4m=muon[0]+muon[1]+muon[2]+muon[3];  
if ( (M4m.M() < 110) ) continue;  
invmass->Fill(M4m.M());
```

```
// Variables  
TLorentzVector muon[5];  
TLorentzVector M4m;  
TLorentzVector Mz1; TLorentzVector Mz2;
```



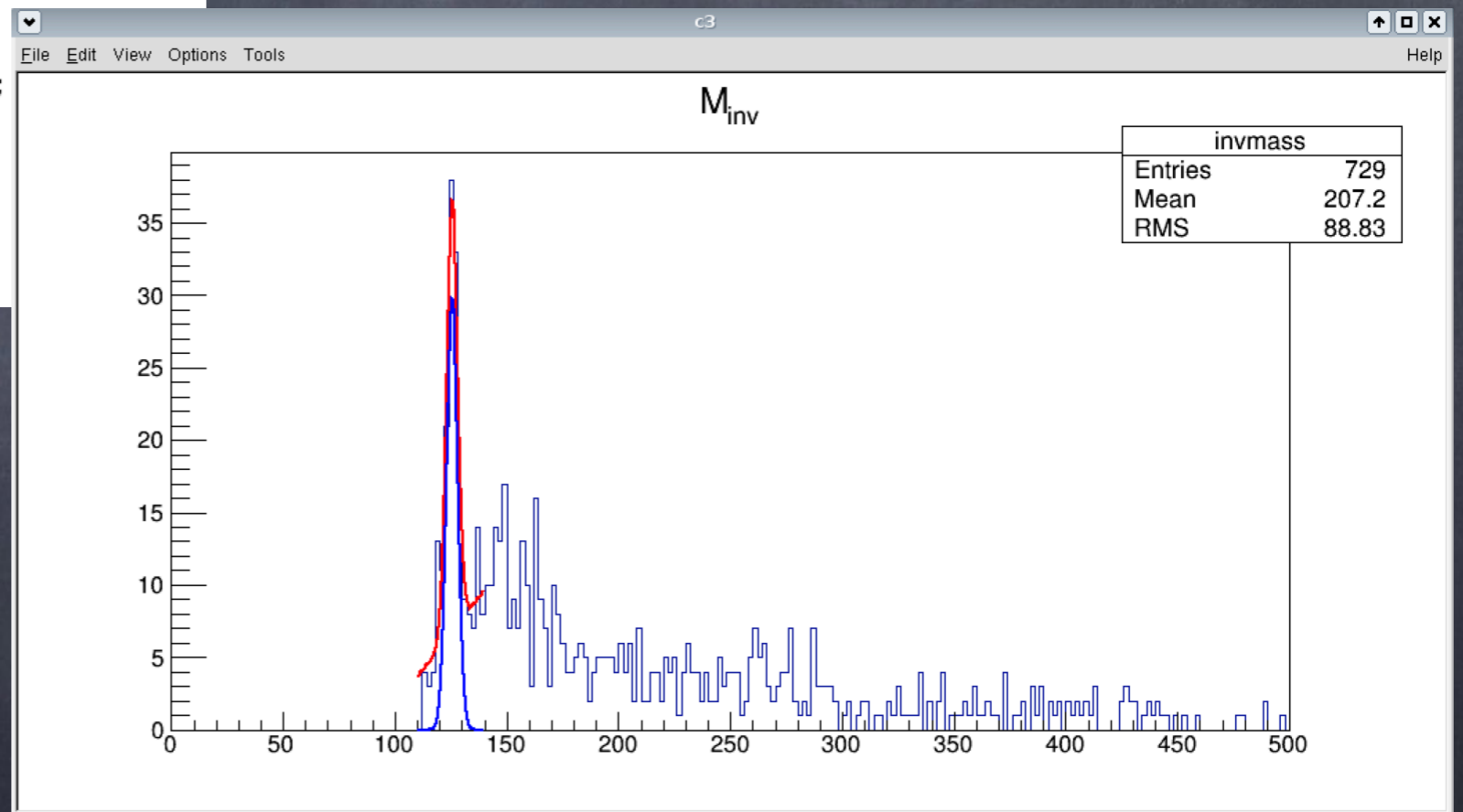
Çözümleme - Fit

```
TF1 *total = new TF1("total", "pol1(0)+gaus(2)",110,140);
total->SetFillColor(4);
total->SetLineWidth(2);
total->SetParameters(-3.5,0.3,30,125,3.5);
total->SetParLimits(2, 26, 34);
total->SetParLimits(3, 124, 126);
total->SetParLimits(4, 2.5, 4.5);
invmass->Fit(total,"WR");
```

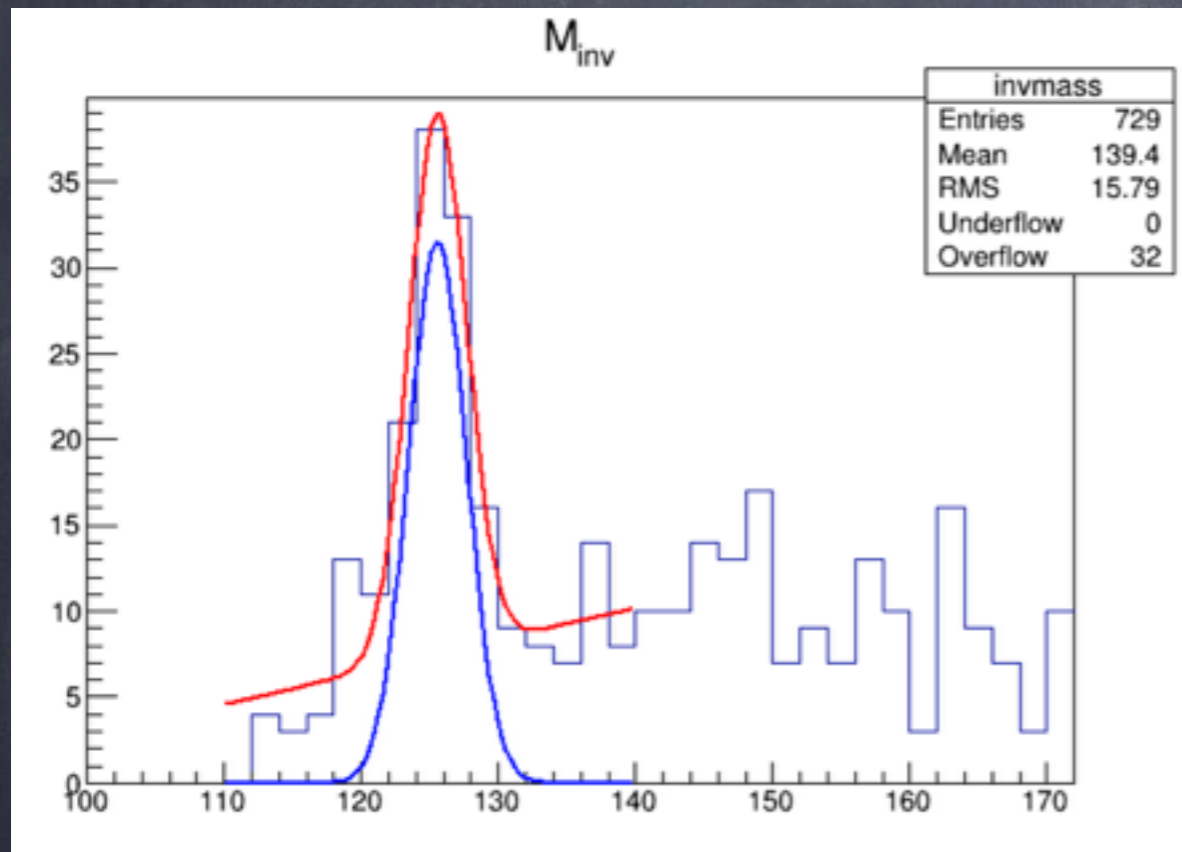
```
Double_t par[5];
total->GetParameters(&par[0]);
```

```
TF1 *signal = new TF1("signal", "gaus",110,140);
signal->SetParameters(&par[2]);
signal->SetLineColor(4);
signal->Draw("same");
```

```
Double_t sig = (signal->Integral(120,130))/2;
std::cout << "sig = " << sig << std::endl;
```



Çözümleme - Fit



```

TF1 *total = new TF1("total", "pol1(0)+gaus(2)", 110, 140);
total->SetFillColor(4);
total->SetLineWidth(2);
total->SetParameters(-3.5, 0.3, 30, 125, 3.5);
//total->SetParLimits(2, 26, 34);
//total->SetParLimits(3, 124, 126);
//total->SetParLimits(4, 2.5, 4.5);
invmass->Fit(total, "WR");

Double_t par[5];
total->GetParameters(&par[0]);

TF1 *signal = new TF1("signal", "gaus", 110, 140);
signal->SetParameters(&par[2]);
signal->SetLineColor(4);
signal->Draw("same");

Double_t sig = (signal->Integral(120, 130)/2);
std::cout << "sig = " << sig << std::endl;

```

```

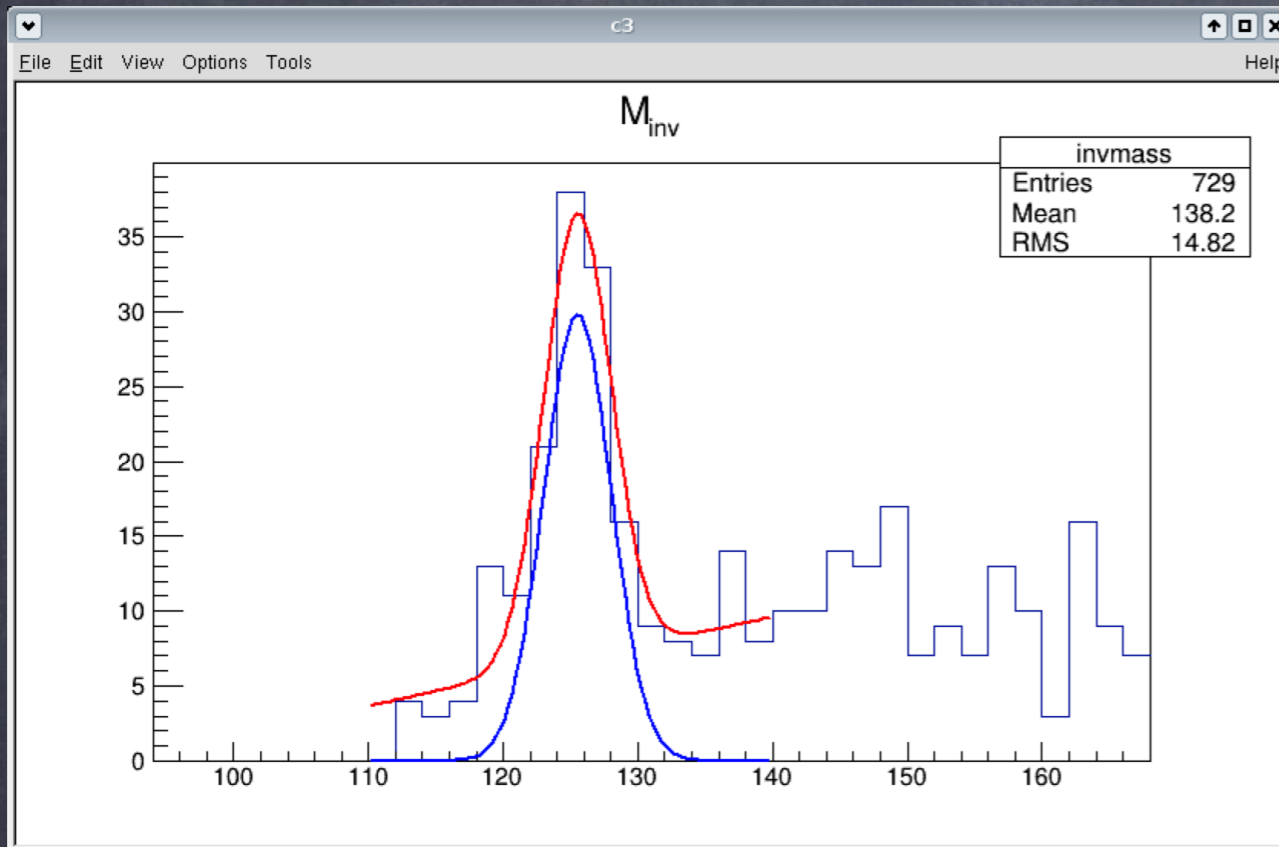
FCN=86.083 FROM MIGRAD   STATUS=CONVERGED   217 CALLS   218 TOTAL
                   EDM=2.0457e-09   STRATEGY= 1   ERROR MATRIX ACCURATE
EXT  PARAMETER
NO.  NAME      VALUE      ERROR      STEP      FIRST
1    p0       -1.61784e+01  4.29406e+00  1.21779e-03  -3.49552e-05
2    p1        1.88371e-01  3.38466e-02  9.64528e-06  -4.00374e-03
3    p2        3.15003e+01  9.45848e-01  3.33401e-03  -1.07442e-05
4    p3        1.25562e+02  7.11401e-02  3.15443e-04  8.96618e-04
5    p4       -2.10766e+00  8.54098e-02  2.71374e-04  1.66704e-04

```

sig = 81.3976



Çözümleme - Fit



```
TF1 *total = new TF1("total", "pol1(0)+gaus(2)",110,140);
total->SetFillColor(4);
total->SetLineWidth(2);
total->SetParameters(-3.5,0.3,30,125,3.5);
total->SetParLimits(2, 26, 34);
total->SetParLimits(3, 124, 126);
total->SetParLimits(4, 2.5, 4.5);
invmass->Fit(total,"WR");

Double_t par[5];
total->GetParameters(&par[0]);

TF1 *signal = new TF1("signal", "gaus",110,140);
signal->SetParameters(&par[2]);
signal->SetLineColor(4);
signal->Draw("same");

Double_t sig = (signal->Integral(120,130)/2);
std::cout << "sig = " << sig << std::endl;
```

```
FCN=103.026 FROM MIGRAD   STATUS=CONVERGED   244 CALLS   245 TOTAL
                    EDM=4.60901e-10   STRATEGY= 1   ERROR MATRIX ACCURATE

EXT  PARAMETER
NO.  NAME      VALUE      ERROR      STEP      FIRST
      NAME      VALUE      ERROR      SIZE      DERIVATIVE
  1  p0        -1.81929e+01  4.32138e+00  1.33100e-03  2.09861e-05
  2  p1         1.98639e-01  3.41390e-02  1.05419e-05  2.86492e-03
  3  p2         2.97775e+01  8.07764e-01  8.37752e-04 -4.55264e-05
  4  p3         1.25510e+02  7.82099e-02  4.40554e-04  2.59870e-04
  5  p4         2.50000e+00  1.29169e-02  8.01377e-04** at limit **

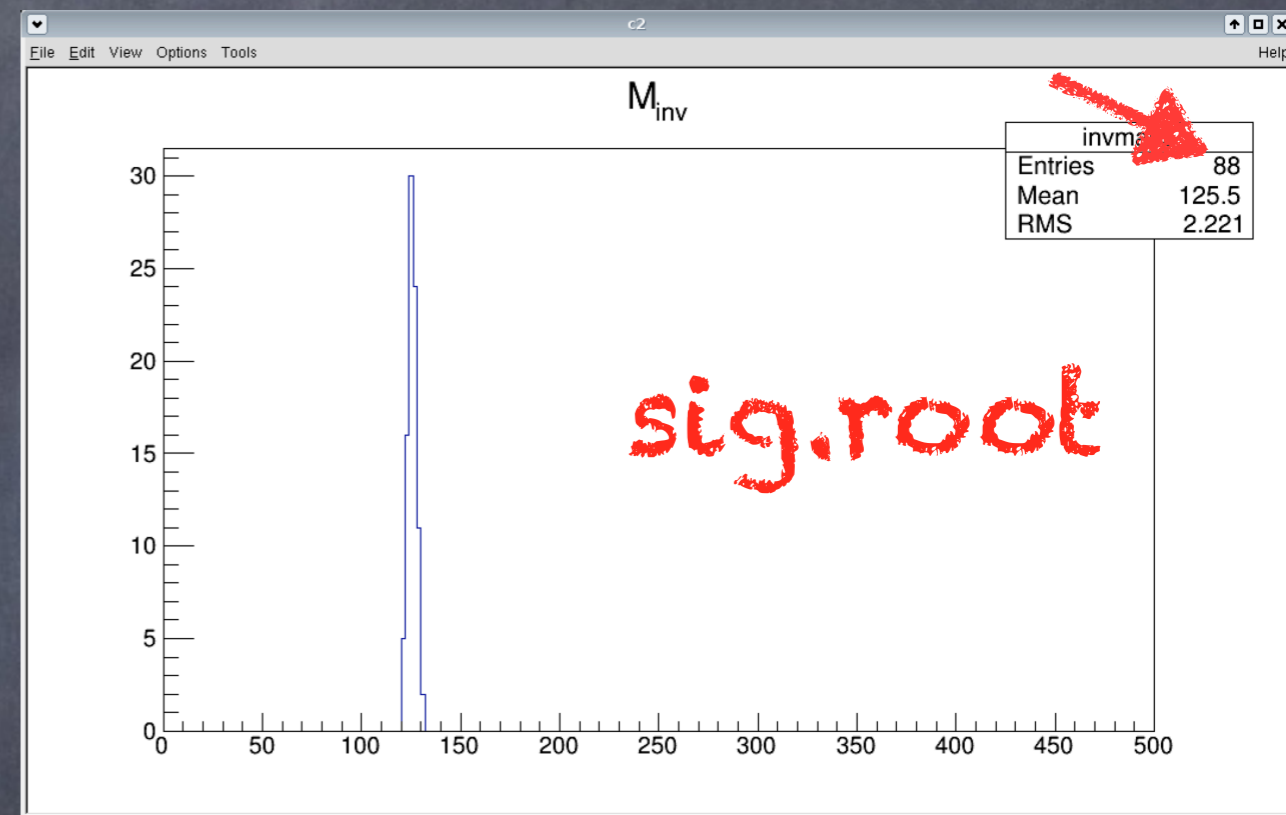
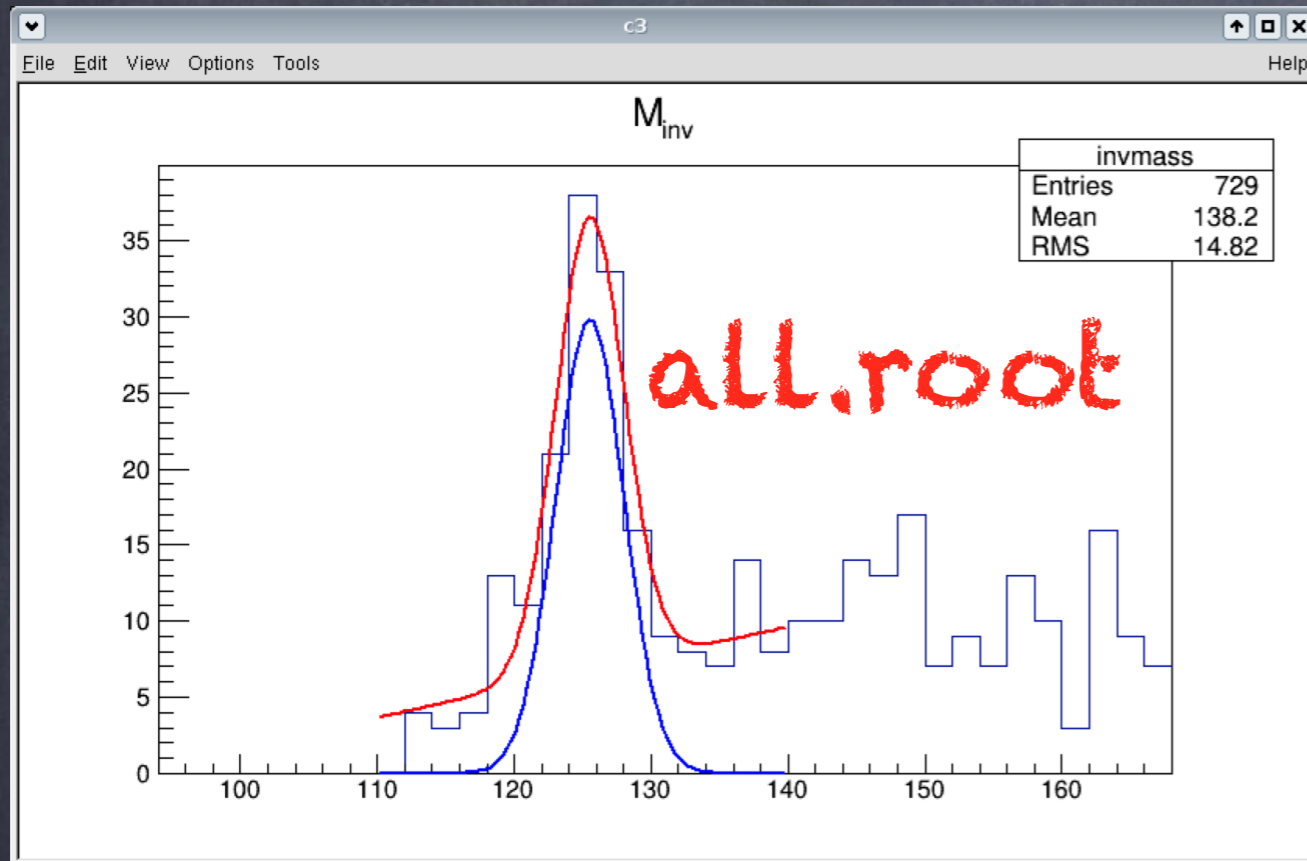
sig = 88.6363
```



Çözümleme - Sinyal dosyası ile kıyaslama

- Başlangıçta hem sinyal hem ardalara içeren dosyayı incelemeye karar vermiştik
- Şimdi ise sadece sinyal içeren dosyaya bakalım
- Sayfa 9 dan buraya kadar olan çözümlemeyi sadece sinyal dosyası için yaparsak ne görürdük?

Çözümleme - Sinyal dosyası ile kıyaslama



```

FCN=103.026 FROM MIGRAD   STATUS=CONVERGED   244 CALLS   245 TOTAL
                        EDM=4.60901e-10   STRATEGY= 1   ERROR MATRIX ACCURATE
EXT PARAMETER          STEP      FIRST
NO.  NAME              VALUE      ERROR    SIZE    DERIVATIVE
  1  p0                 -1.81929e+01  4.32138e+00  1.33100e-03  2.09861e-05
  2  p1                  1.98639e-01  3.41390e-02  1.05419e-05  2.86492e-03
  3  p2                  2.97775e+01  8.07764e-01  8.37752e-04  -4.55264e-05
  4  p3                  1.25510e+02  7.82099e-02  4.40554e-04  2.59870e-04
  5  p4                  2.50000e+00  1.29169e-02  8.01377e-04** at limit **
sig = 88.6363
    
```



Çözümleme - Birkaç soru

- Gauss parametrelerinin limitlerini değiştirmek sonucu nasıl etkiler?
- Gauss yerine başka bir fonksiyon kullansaydık sonuç nasıl değişirdi?
- Uyguladığımız tirpanların ardalan ve sinyal üzerine etkisi nedir? Başka tirpanlar kullanarak aynı sonuca ulaşmak mümkün olur mu?
- Bütün bu soruların cevaplarını ödevi gözerken değerlendirmenizi istiyorum!!
- ATLAS Higgs sinyalini nasıl gözlemledi?
<https://twiki.cern.ch/twiki/pub/AtlasPublic/HiggsPublicResults//41-FixedScale-NoMuProf2.gif>