YENİ FİZİK Z-PRİME ARAŞTIRMASI

- PFBU 2020

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Danışman
İlkay TÜRK ÇAKIR

NEDİR BU Z’?

Kuantum seviyesinde maddeler arasındaki etkileşim parçacık değişimleri ile gerçekleşir.

Bu kuvvet taşıyıcı parçacıklara bozon denir.

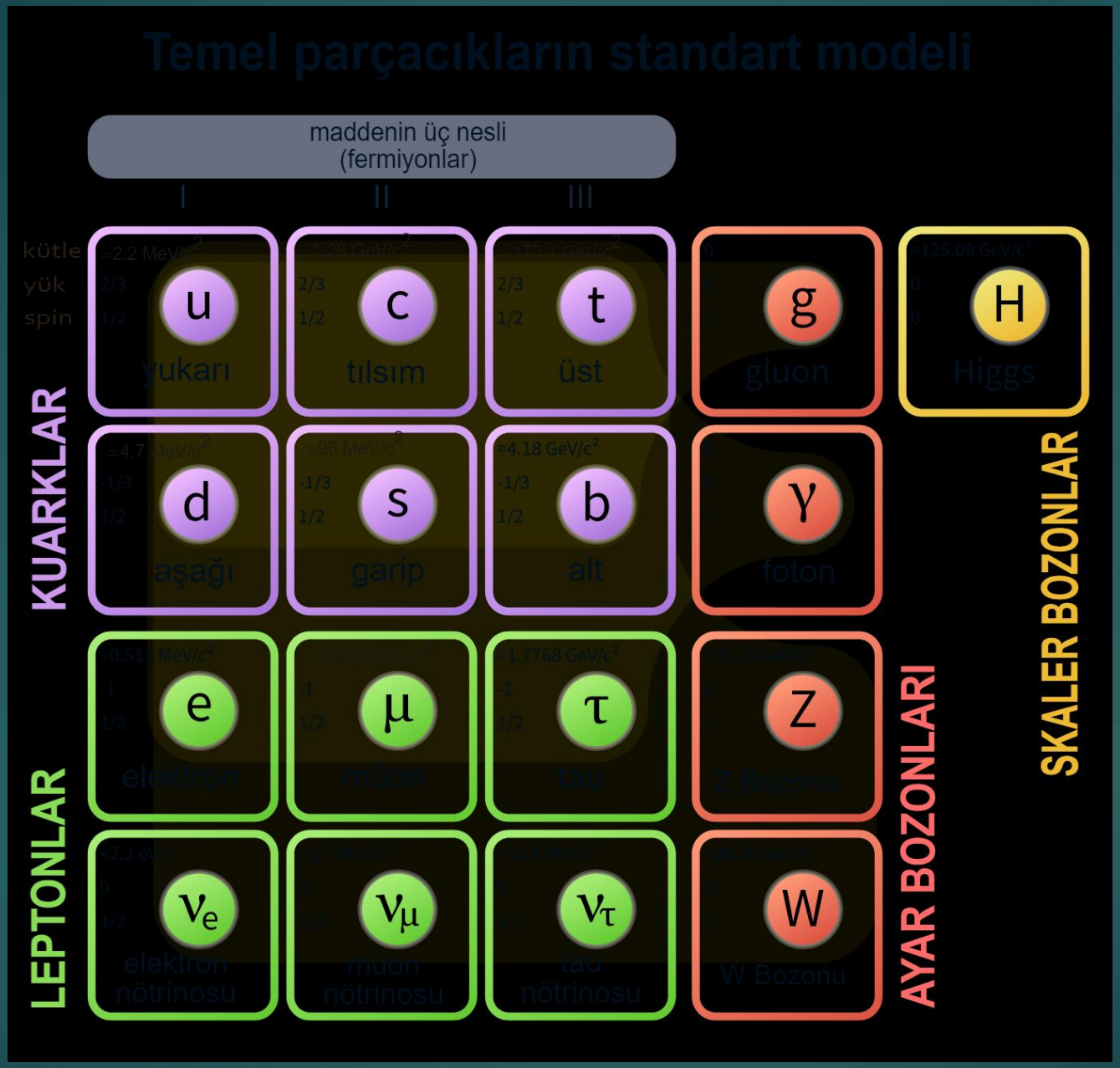
Farklı kuvvetlerin farklı taşıyıcı bozonları vardır.

Zayıf nükleer kuvvet W ve Z bozonları ile taşınır.

Eğer varsa, Z’ bozonu Z nin ağır bir versiyonu gibidir.

Kuramsal fizikçiler birçok farklı sebepten ötürü Z’ bozonunun var olması gerektiğini savunur.

Ve bunu bulmak bize yepyeni ve heyecan verici bir fiziğin varlığını gösterebilir.


Temel parçacıkların standart modeli
maddenin üç nesli
(fermiyonlar)
I
II
III
kütle
yük
spin
KUARKLAR
u
yukarı
c
tılsım
t
üst
g
gluon
H
Higgs
d
aşağı
s
garip
b
alt
γ
foton
LEPTONLAR
e
elektron
μ
müon
τ
tau
Z
Z Bozonu
AYAR BOZONLARI
SKALER BOZONLAR
νe
elektron nötrinosu
νμ
müon nötrinosu
ντ
tau nötrinosu
W
W Bozonu

Search for resonances decaying into top-quark pairs using fully hadronic decays in pp collisions with ATLAS at $\sqrt{s} = 7$ TeV

The ATLAS collaboration

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ABSTRACT: A search for resonances produced in 7 TeV proton-proton collisions and decaying into top-quark pairs is described. In this Letter events where the top-quark decay produces two massive jets with large transverse momenta recorded with the ATLAS detector at the Large Hadron Collider are considered. Two techniques that rely on jet substructure are used to separate top-quark jets from those arising from light quarks and gluons. In addition, each massive jet is required to have evidence of an associated bottom-quark decay. The data are consistent with the Standard Model, and limits can be set on the production cross section times branching fraction of a Z' boson and a Kaluza-Klein gluon resonance. These limits exclude, at the 95% credibility level, Z' bosons with masses 0.70-1.00 TeV as well as 1.28-1.32 TeV and Kaluza-Klein gluons with masses 0.70-1.62 TeV.

1 Introduction

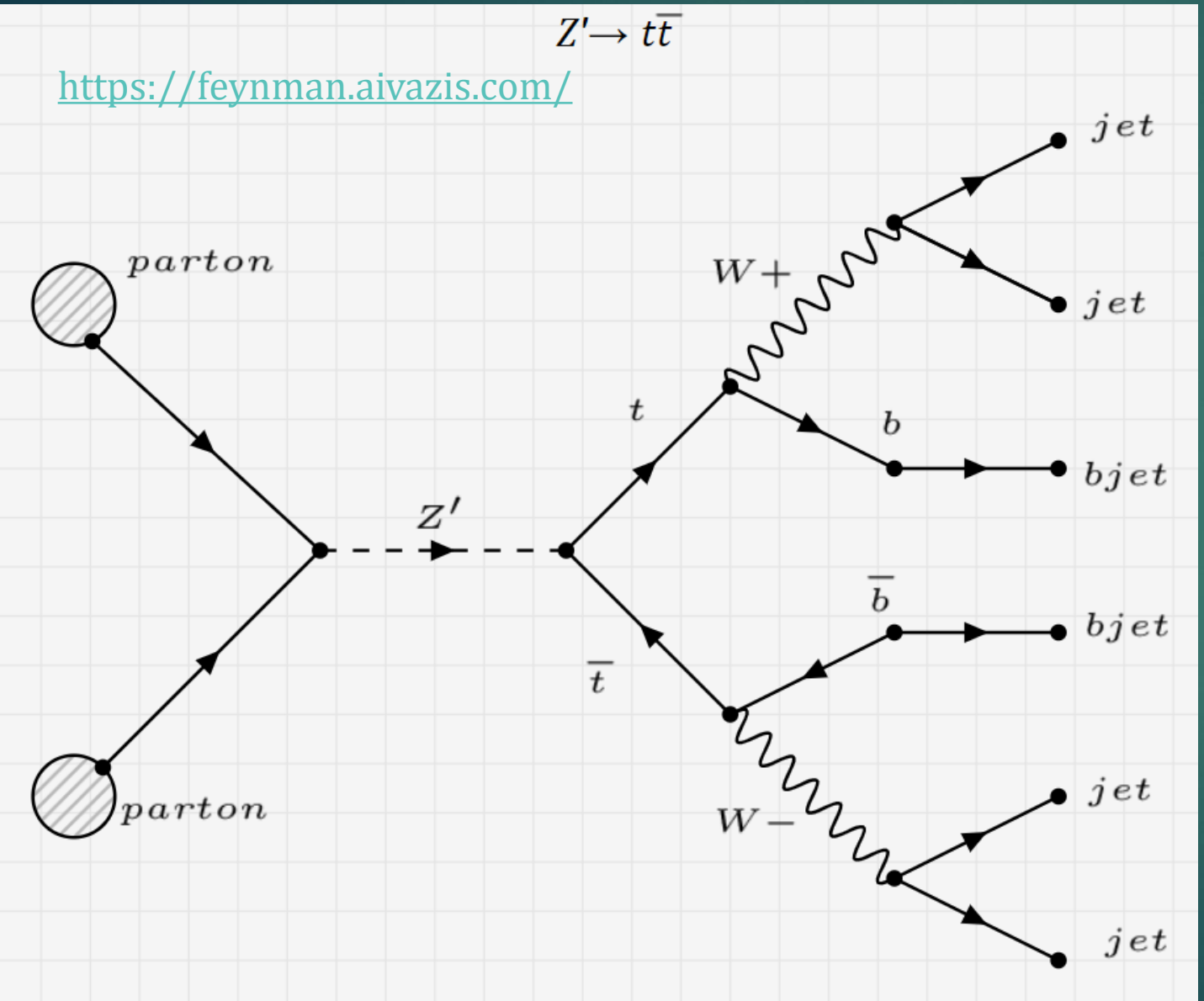
Many models of new phenomena beyond the Standard Model (SM) predict resonances in the TeV mass range that decay primarily into top-antitop quark pairs[1] ($t\bar{t}$). This Letter reports on a search for such phenomena in proton-proton (pp) collisions at the Large Hadron Collider (LHC) where both top quarks are reconstructed in their fully hadronic final states and have large transverse momentum (p_{T}). The decay products of each high-p_{T} top quark are collimated and merge into one jet with large invariant mass.

Previous searches mostly considered cases where in one or both of the top-quark decays, the intermediate W boson decays leptonically and hence the top-quark decays result in one or two isolated leptons, missing energy from the neutrinos, and jets in the final state [1–8]. The requirements of a well-identified charged lepton isolated from nearby hadronic energy deposits and missing transverse energy reject a large fraction of background from multijet production. However, difficulties arise in these final states when the top-quark decay particles are collimated, since leptons from the top-quark decay are no longer isolated and thus background contributions with lepton candidates originating from hadronic jets are more difficult to distinguish from the signal.

An alternative approach that is reported in this Letter is to consider final states with high-p_{T} top quarks that decay hadronically and where the decay products are collimated in the direction of the top-quark. Such searches require the top quarks to have p_{T} in excess of 200-300 GeV and require rejection of the large background of gluon jets, light-quark jets, as well as c- and b-jets. The CMS Collaboration employed this technique in a recent study [9].

- Yüksek enine momentumlu jetler
- Yüksek enine momentumlu top quarklar (+200 GeV)

Sinyal



- 7 TeV proton - proton çarpışması
- Tam hadronik top kuark bozunumu
- Yüksek enine momentumlu jetler (+200 GeV)
- b-jet ler dahil en az 6 jet
- Rezonans durumu olmasından zıt yönlü top quarklar

Z’ Yapılandırma Algoritması

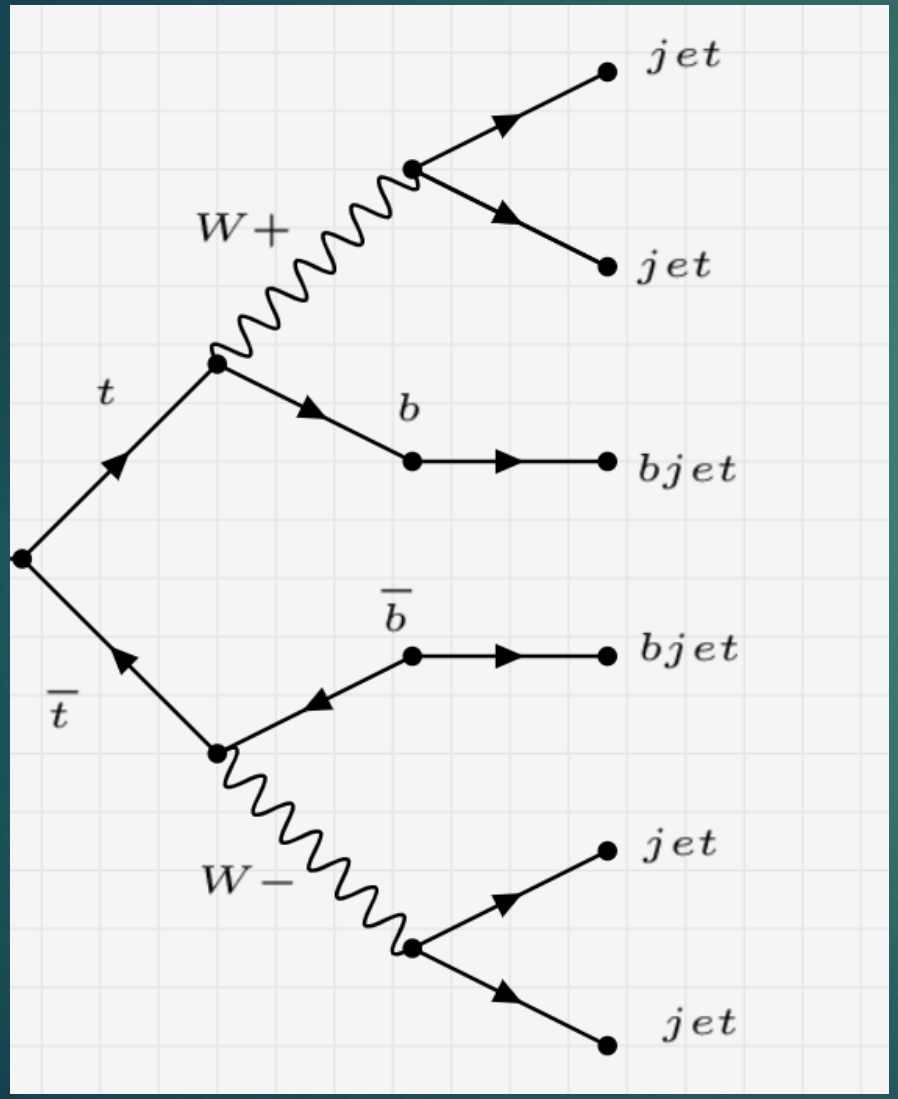

```
define   WH1  : JET[-1] JET[-1]
define   WH2  : JET[-3] JET[-3]

###      chi2 for W finder
define   Wchi2 : (({WH1}m - 80.4)/2.1)^2 + (({WH2}m - 80.4)/2.1)^2

## top quarks without b tagging
define   Top1 : WH1 JET[-2]
define   Top2 : WH2 JET[-4]

## top mass
define   mTop1 : m(Top1)
define   mTop2 : m(Top2)

## ZP mass
define   ZP   : Top1 Top2
define   mZP : m(ZP)

###      chi2 for top finder
define   topchi2 : ((mTop1 - mTop2)/4.2)^2
define   ZPchi2  : ((mZP - 750.0)/10.0)^2

algo bestop
  select   ALL                                  # to count all events
  select   Size(JET) >= 6                       # at least 6 jets
  select   MET < 200                            # no large MET
  select   {JET}Pt > 25
  select   AbsEta(JET_) < 2.5
  select   Wchi2 + topchi2 ~= 0                 # find the tops and ws and ZP
  select   {Top1 , Top2}dR [] 2.5 3.5           # angular selection
  select   {Top1}Pt > 175                       # Momentum must be high enough to reconstruct Z prime
  select   {Top2}Pt > 175

  histo    hmWH1 ,  "Hadronic W recovery (GeV)", 50, 50, 150, m(WH1)
  histo    hmWH2 ,  "Hadronic W recovery (GeV)", 50, 50, 150, m(WH2)
  histo    hmTop1 , "Hadronic top recovery (GeV)", 70, 0, 700, mTop1
  histo    hmTop2 , "Hadronic top recovery (GeV)", 70, 0, 700, mTop2
  select   Wchi2 + topchi2 + ZPchi2 ~= 0 # find the tops and ws and ZP
  histo    hmZP ,   "Hadronic ZPrime recovery (GeV)", 50, 100, 2000, mZP
```

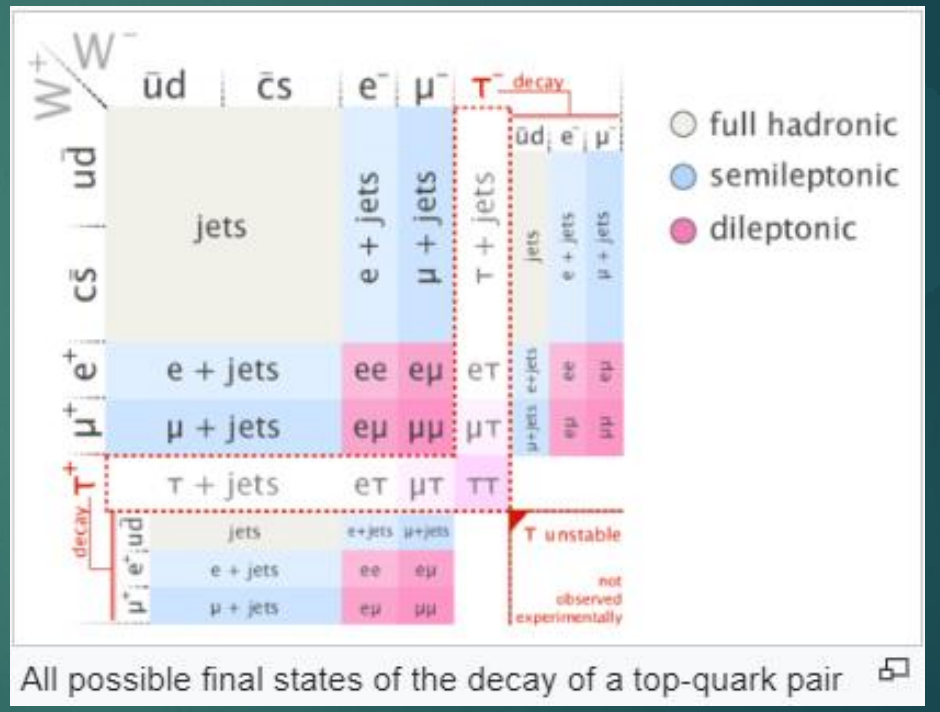
Data

Set of MonteCarlo (MC) samples

File type	Name	Description	Last modified	Size	# Events
	mc_105985.WW.root	Diboson process *WW*	21-Jul-2016 16:00	64,7Mb	500000
	mc_105986.ZZ.root	Diboson process *ZZ*	21-Jul-2016 16:00	19,8Mb	125000
	mc_105987.WZ.root	Diboson process *WZ*	21-Jul-2016 16:00	69,5Mb	500000
	mc_110090.stop_tchan_top.root	Single top *t*-channel top	21-Jul-2016 16:00	21,6Mb	150000
	mc_110091.stop_tchan_antitop.root	single top *t*-channel antitop	21-Jul-2016 16:00	14,5Mb	150000
	mc_110119.stop_schan.root	single top *s*-channel	21-Jul-2016 16:00	15,1Mb	100000
	mc_110140.stop_wtchan.root	single top *Wt*-channel	21-Jul-2016 16:00	26,4Mb	150000
	mc_110899.ZPrime400.root	$Z' \rightarrow t\bar{t}$ with $M_{Z'} = 400$ GeV	21-Jul-2016 16:00	4,4Mb	21941
	mc_110901.ZPrime500.root	$Z' \rightarrow t\bar{t}$ with $M_{Z'} = 500$ GeV	21-Jul-2016 16:00	4,8Mb	23231
	mc_110902.ZPrime750.root	$Z' \rightarrow t\bar{t}$ with $M_{Z'} = 750$ GeV	21-Jul-2016 16:00	5,4Mb	25021
	mc_110903.ZPrime1000.root	$Z' \rightarrow t\bar{t}$ with $M_{Z'} = 1000$ GeV	21-Jul-2016 16:00	5,7Mb	25525
	mc_110904.ZPrime1250.root	$Z' \rightarrow t\bar{t}$ with $M_{Z'} = 1250$ GeV	21-Jul-2016 16:00	5,6Mb	25030
	mc_110905.ZPrime1500.root	$Z' \rightarrow t\bar{t}$ with $M_{Z'} = 1500$ GeV	21-Jul-2016 16:00	5,5Mb	24142
	mc_110906.ZPrime1750.root	$Z' \rightarrow t\bar{t}$ with $M_{Z'} = 1750$ GeV	21-Jul-2016 16:00	5,2Mb	23084
	mc_110907.ZPrime2000.root	$Z' \rightarrow t\bar{t}$ with $M_{Z'} = 2000$ GeV	21-Jul-2016 16:00	5,0Mb	21997
	mc_110908.ZPrime2250.root	$Z' \rightarrow t\bar{t}$ with $M_{Z'} = 2250$ GeV	21-Jul-2016 16:00	4,8Mb	21127
	mc_110909.ZPrime2500.root	$Z' \rightarrow t\bar{t}$ with $M_{Z'} = 2500$ GeV	21-Jul-2016 16:00	4,6Mb	20327
	mc_110910.ZPrime3000.root	$Z' \rightarrow t\bar{t}$ with $M_{Z'} = 3000$ GeV	21-Jul-2016 16:00	4,4Mb	19646
	mc_117049.ttbar_had.root	$t\bar{t} \rightarrow$ Jets	21-Jul-2016 16:00	5,8Mb	25170

Background



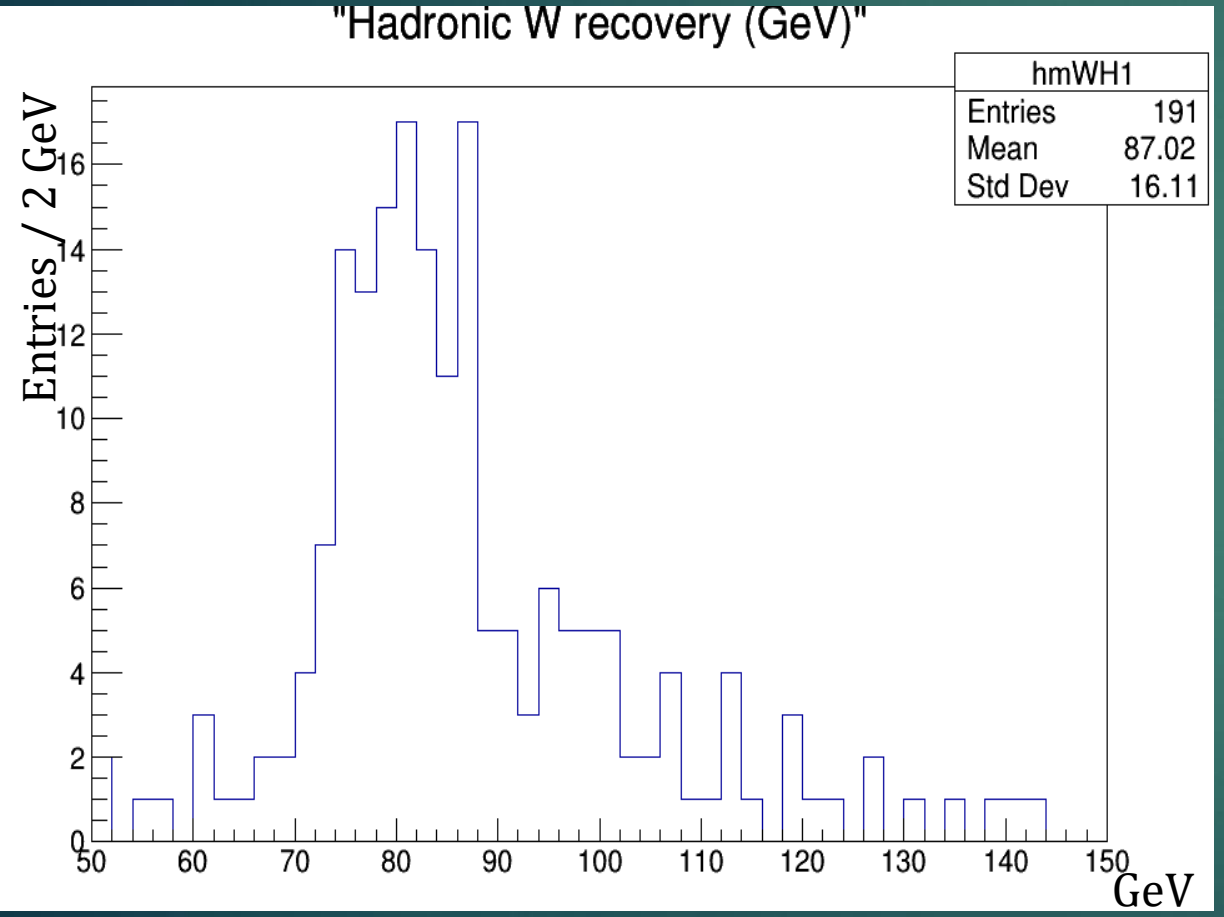


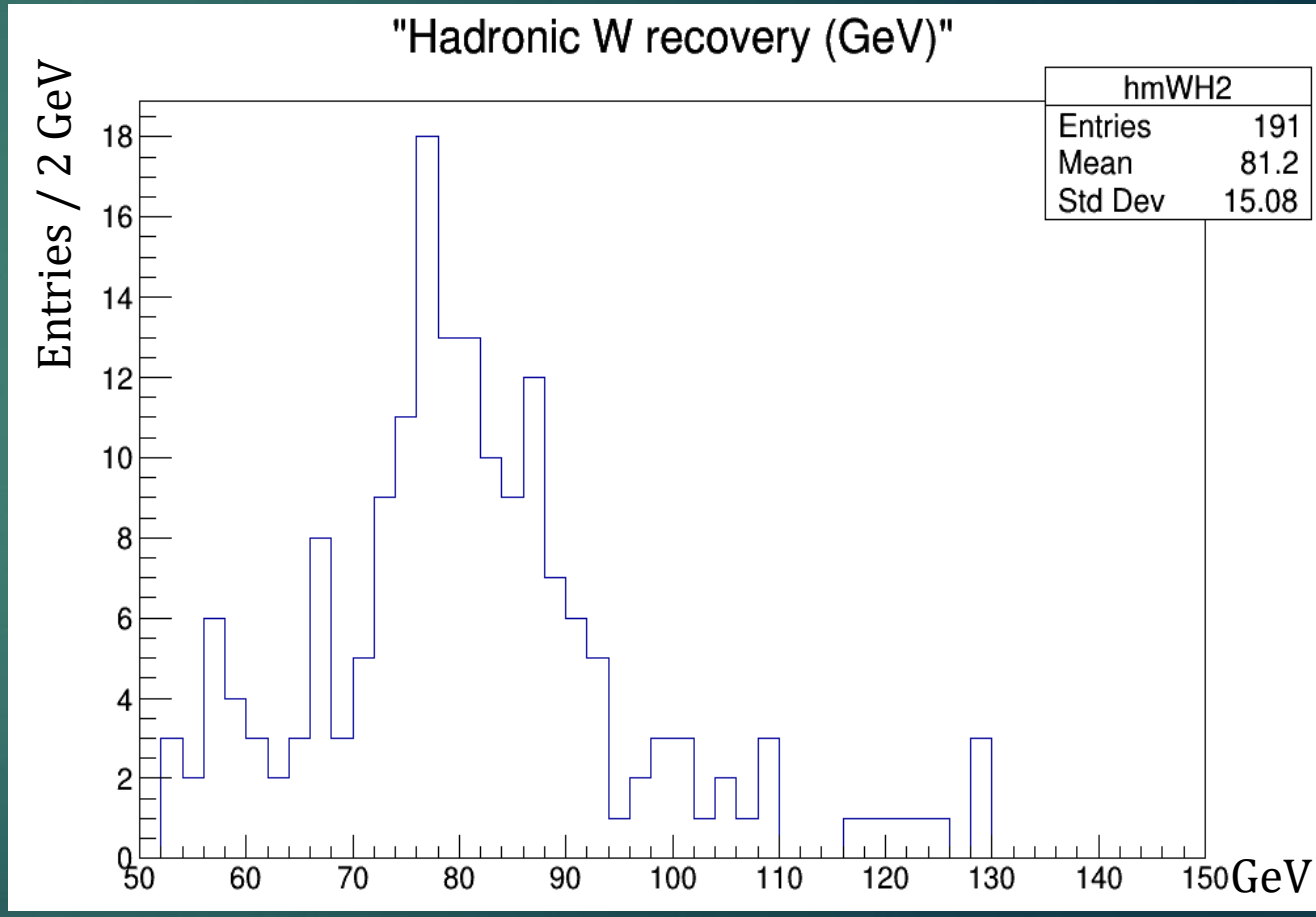
All possible final states of the decay of a top-quark pair

$t\bar{t} \rightarrow Jets$

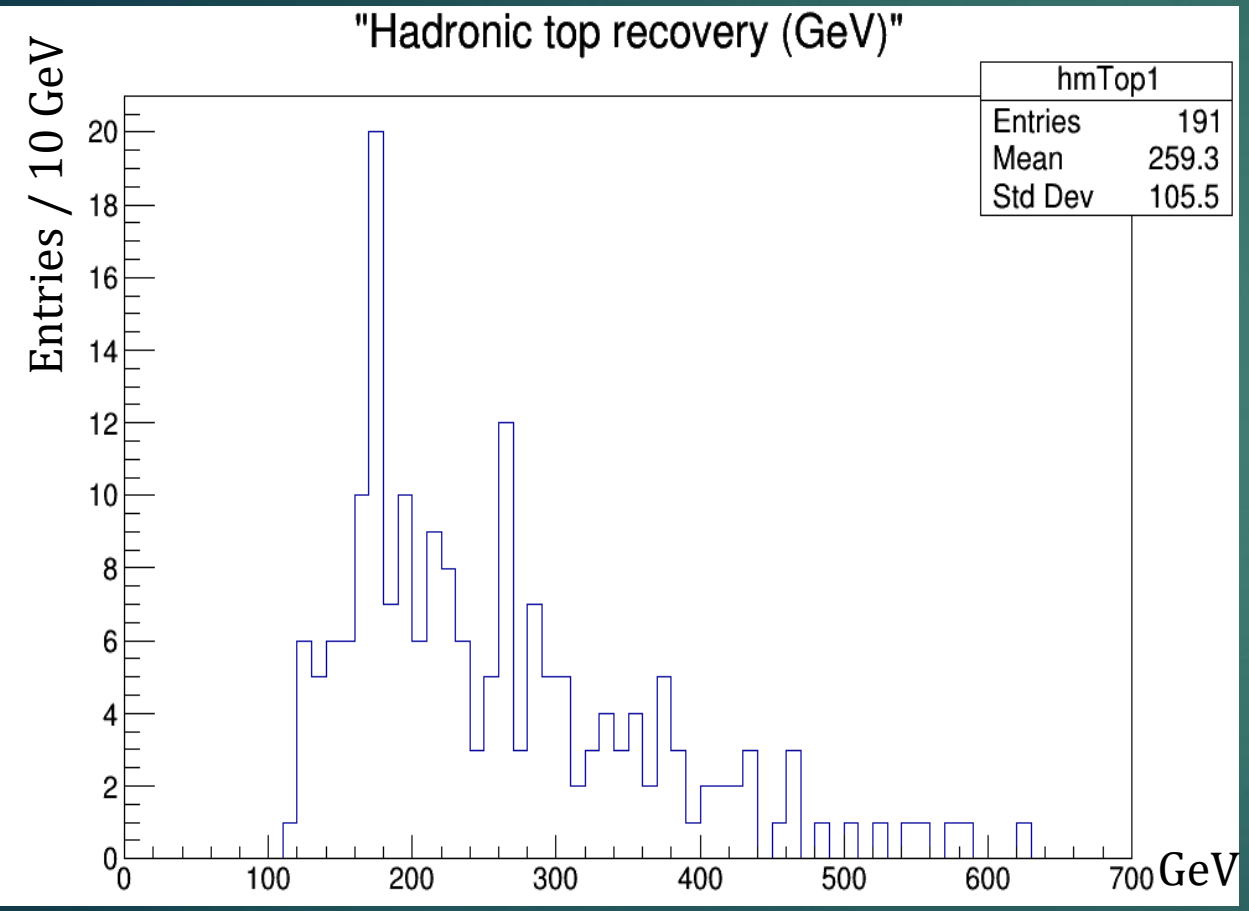

```
Efficiencies for analysis : BP_1
                                                    bestop  Based on 25170 events:
                                                                        ALL :      1 +-          0 evt:    25170
                                                           Size(JET) >= 6 : 0.2274 +-    0.00264 evt:     5724
                                                               MET < 200 : 0.9997 +-   0.000247 evt:     5722
                                                             {JET}Pt > 25 : 0.9509 +-    0.00286 evt:     5441
                                                        AbsEta(JET_) < 2.5 : 0.7192 +-    0.00609 evt:     3913
                                                      Wchi2 + topchi2 ~= 0 :      1 +-          0 evt:     3913
                                                {Top1 , Top2}dR [] 2.5 3.5 : 0.4804 +-    0.00799 evt:     1880
                                                             {Top1}Pt > 175 : 0.2489 +-    0.00997 evt:      468
                                                             {Top2}Pt > 175 : 0.4081 +-     0.0227 evt:      191
                                           [Histo] Hadronic W recovery (GeV) :      1 +-          0 evt:      191
                                           [Histo] Hadronic W recovery (GeV) :      1 +-          0 evt:      191
                                         [Histo] Hadronic top recovery (GeV) :      1 +-          0 evt:      191
                                         [Histo] Hadronic top recovery (GeV) :      1 +-          0 evt:      191
                                              Wchi2 + topchi2 + ZPchi2 ~= 0 :      1 +-          0 evt:      191
                                       [Histo] Hadronic ZPrime recovery (GeV) :      1 +-          0 evt:      191
                                                         --> Overall efficiency  =  0.759 % +- 0.0547 %
```

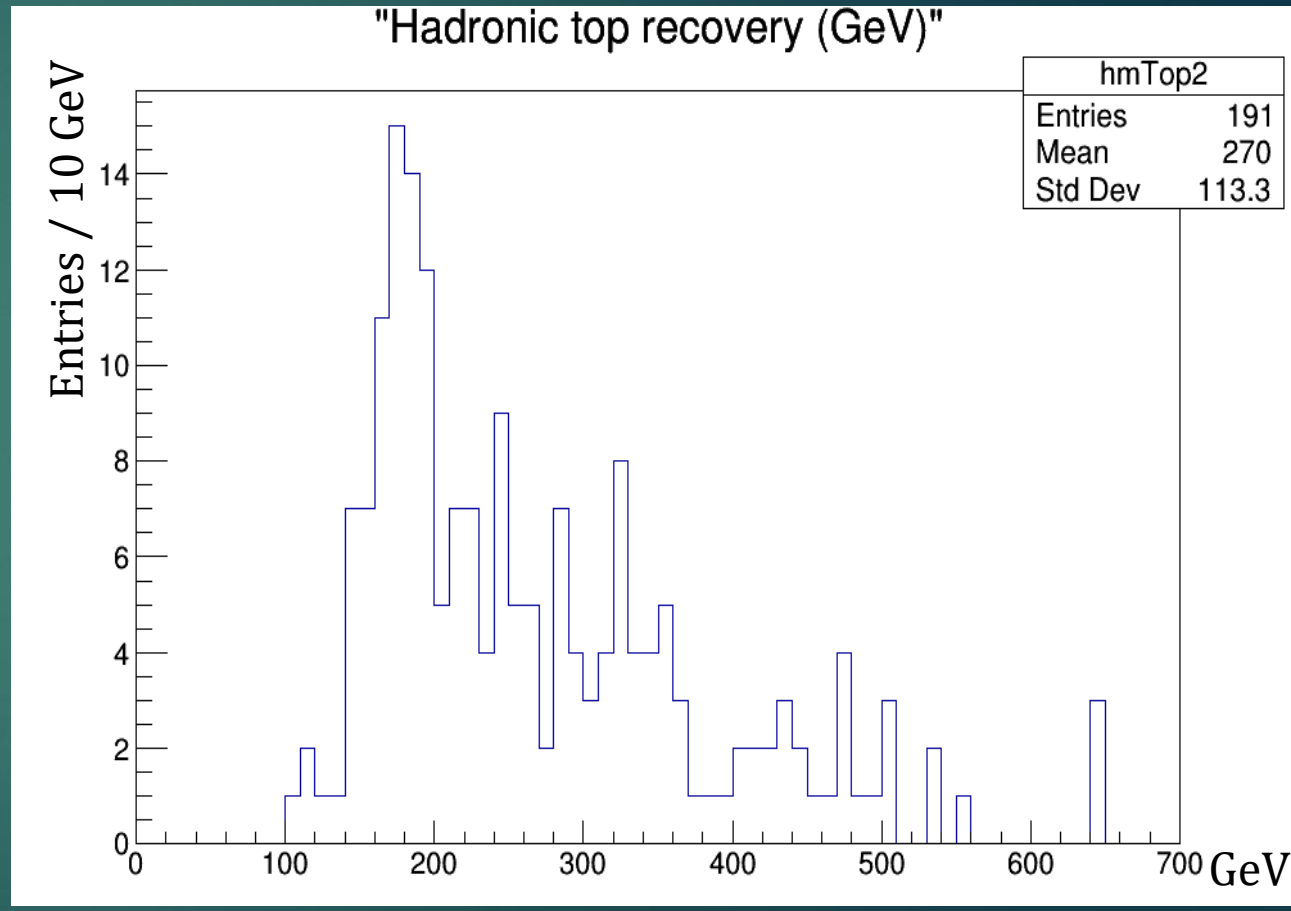
$t\bar{t} \rightarrow Jets$



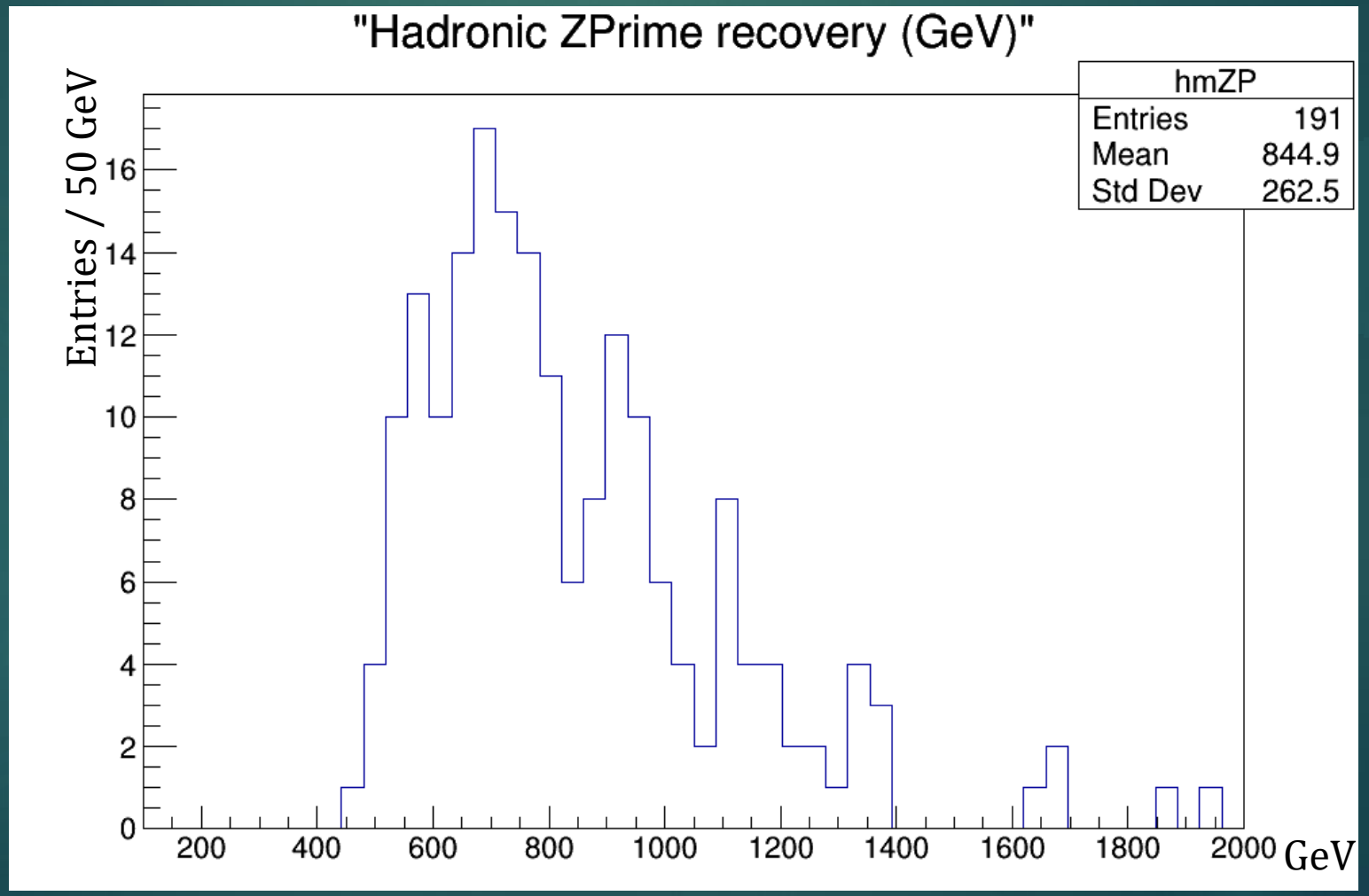


$t\bar{t} \rightarrow Jets$





$t\bar{t} \rightarrow Jets$

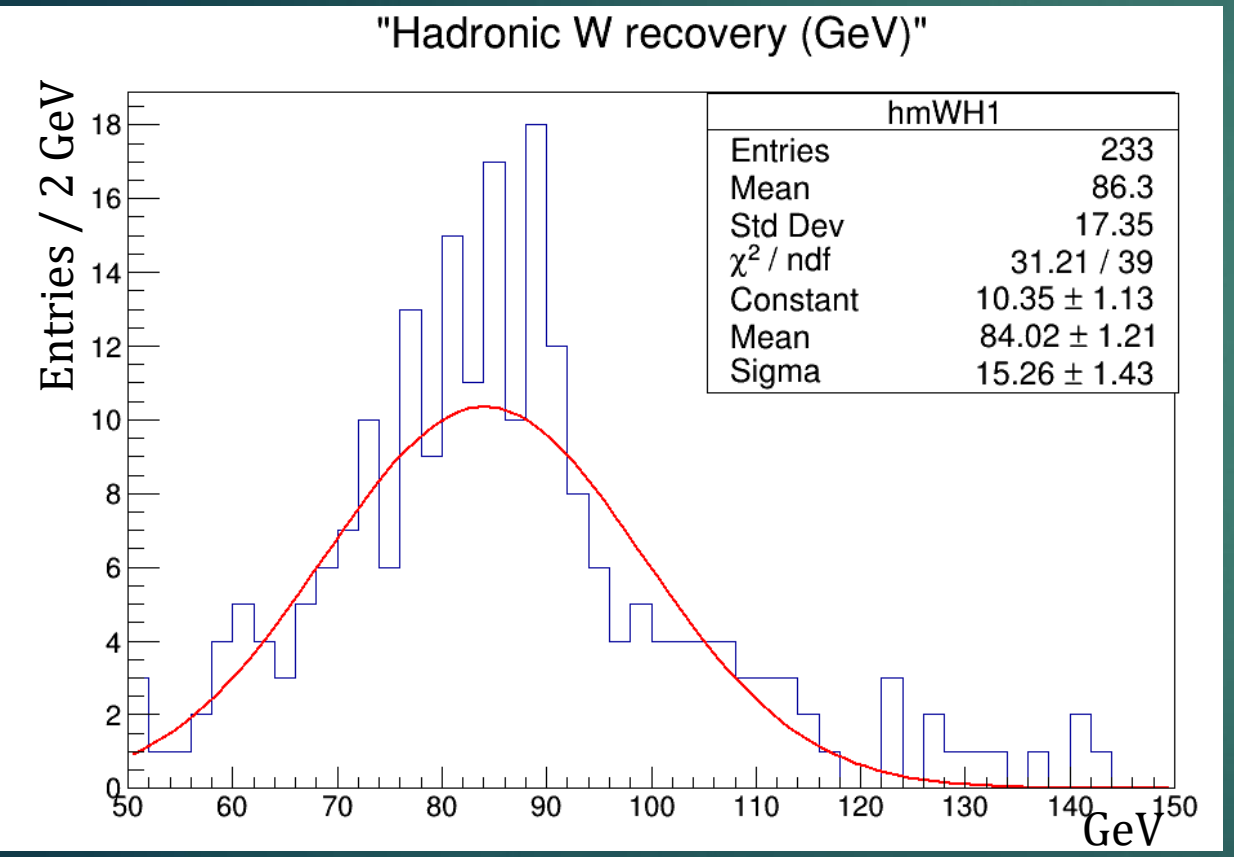


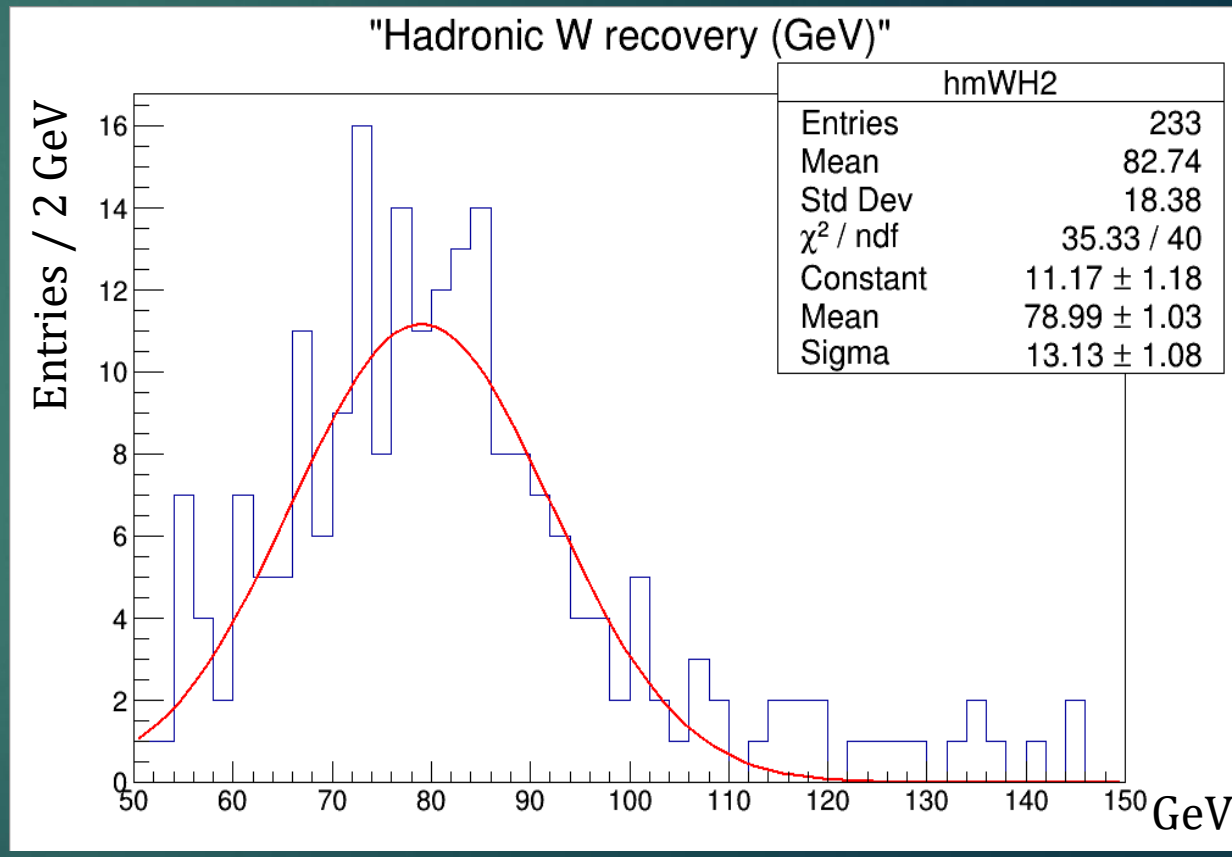
$Z' \rightarrow t\bar{t}$ with $M_{Z'} = 750\ GeV$


```
Efficiencies for analysis : BP_1
                                                bestop  Based on 25007 events:
                                                                   ALL :      1 +-          0 evt:    25007
                                                      Size(JET) >= 6 : 0.1257 +-     0.0021 evt:     3144
                                                           MET < 200 : 0.9291 +-    0.00458 evt:     2921
                                                         {JET}Pt > 25 : 0.9736 +-    0.00296 evt:     2844
                                                  AbsEta(JET_) < 2.5 : 0.8031 +-    0.00746 evt:     2284
                                               Wchi2 + topchi2 ~= 0 :      1 +-          0 evt:     2284
                                           {Top1 , Top2}dR [] 2.5 3.5 : 0.5013 +-     0.0105 evt:     1145
                                                      {Top1}Pt > 175 : 0.6114 +-     0.0144 evt:      700
                                                      {Top2}Pt > 175 : 0.3329 +-     0.0178 evt:      233
                                     [Histo] Hadronic W recovery (GeV) :      1 +-          0 evt:      233
                                     [Histo] Hadronic W recovery (GeV) :      1 +-          0 evt:      233
                                   [Histo] Hadronic top recovery (GeV) :      1 +-          0 evt:      233
                                   [Histo] Hadronic top recovery (GeV) :      1 +-          0 evt:      233
                                        Wchi2 + topchi2 + ZPchi2 ~= 0 :      1 +-          0 evt:      233
                                [Histo] Hadronic ZPrime recovery (GeV) :      1 +-          0 evt:      233
                                           --> Overall efficiency  =  0.932 % +- 0.0608 %
```

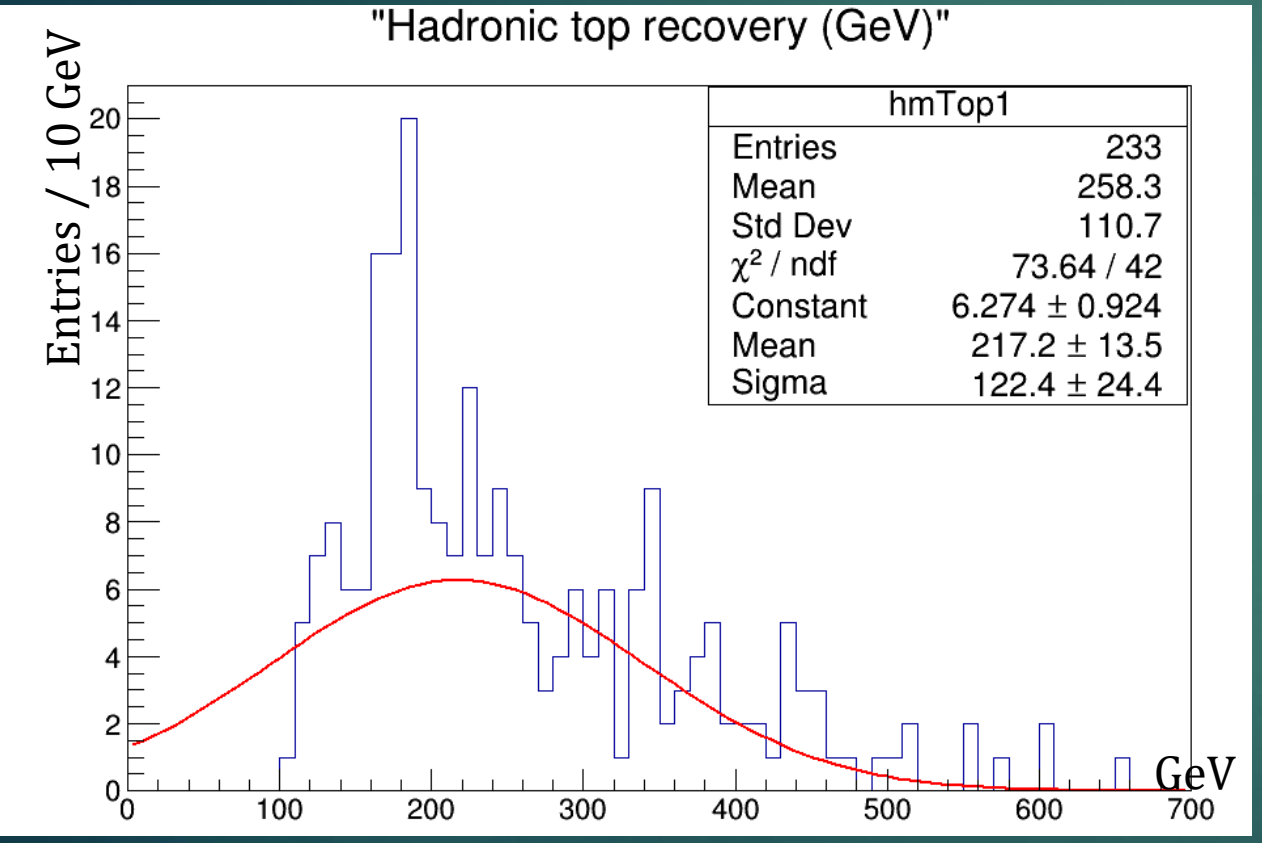
mc_110902.ZPrime750.root	$Z' \rightarrow t\bar{t}$ with $M_{Z'}$ = 750 GeV	21-Jul-2016 16:00	5,4Mb	25021

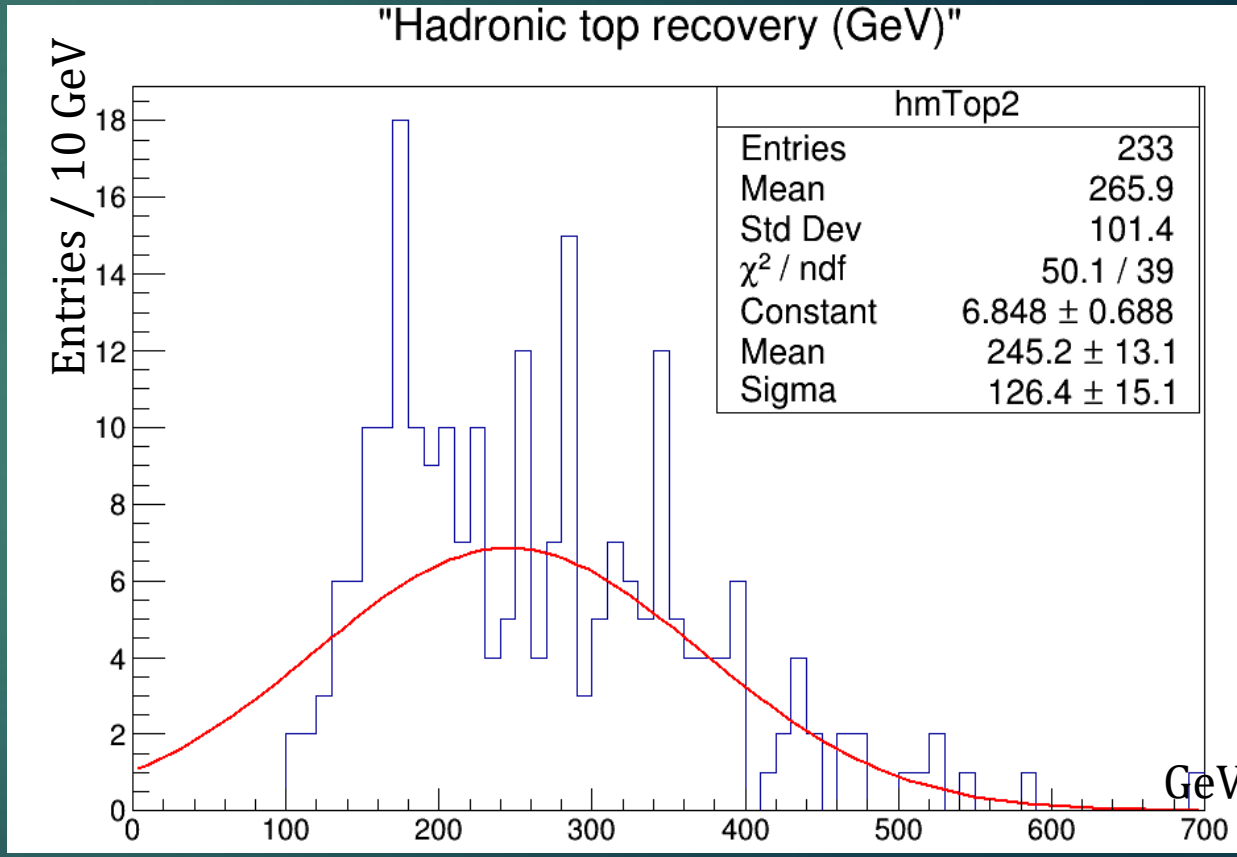
$Z' \rightarrow t\bar{t}$ with $M_{z'} = 750\ GeV$



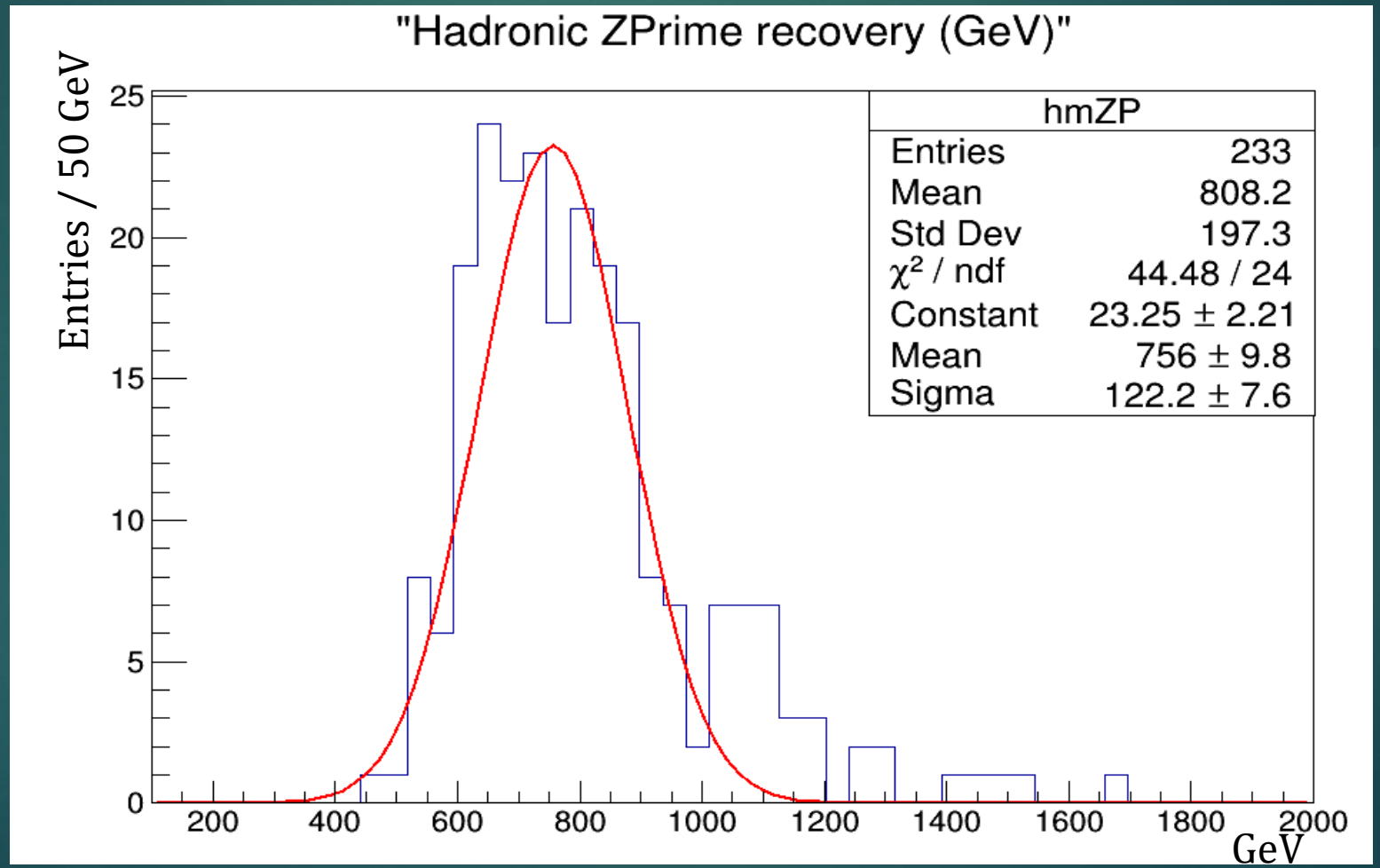


$Z' \rightarrow t\bar{t}$ with $M_{z'} = 750\ GeV$

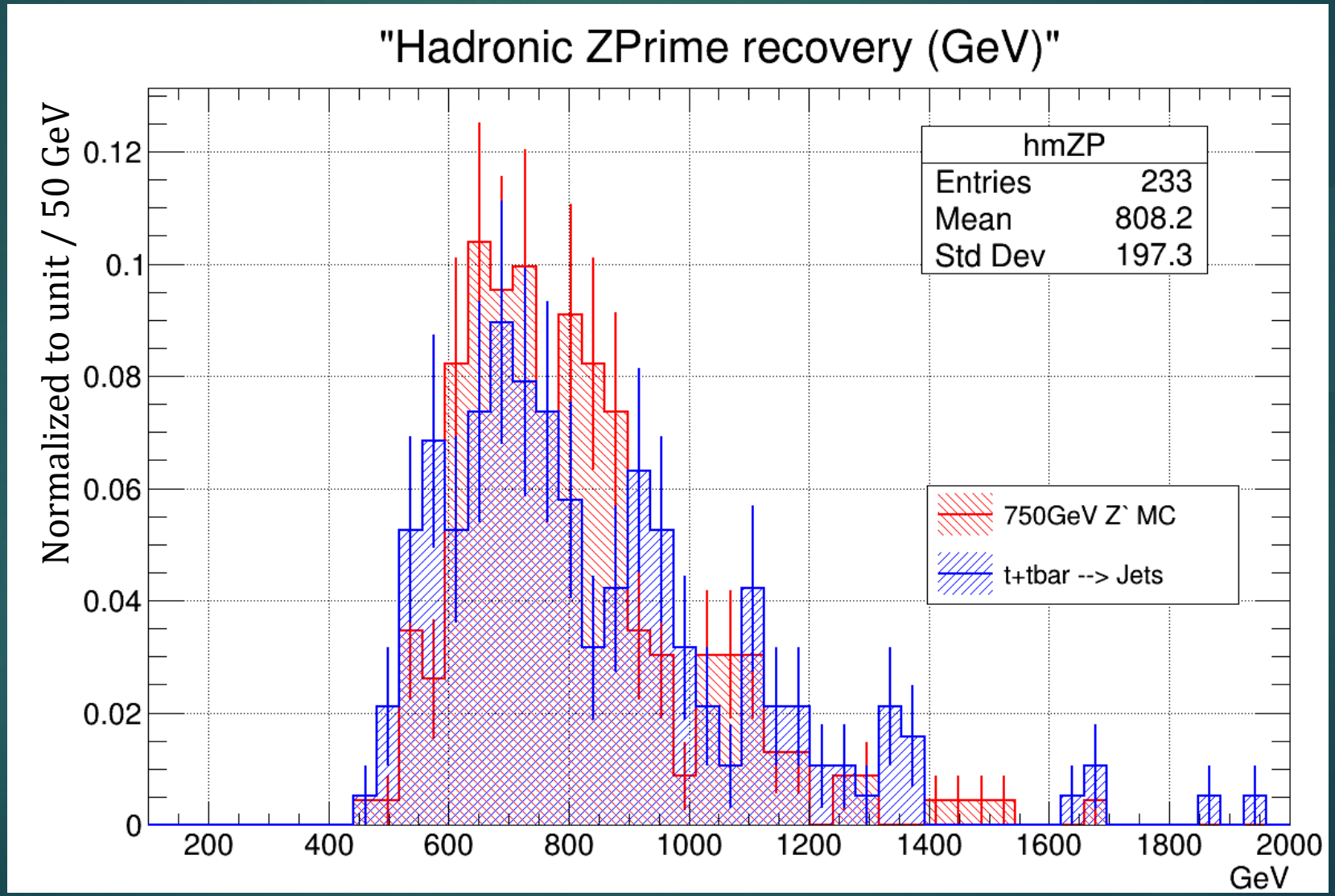




$Z' \rightarrow t\bar{t}$ with $M_{z'} = 750\ GeV$



Signal vs Background



SONUÇ VE YORUM

- Bu çalışmada açık veri (Atlas Open Data) kullanılarak Z prime araştırması yaptık.
- Analizde CutLang kullandık.
- Son durumda 6 jet kullandık. W bozonlarını hadronik modda yapılandırdık.
- Üst kuarkları W bozonlarından ve b jerlerden yapılandırdık.
- İki üst kuark momentumlarından değişmez kütle (invariant mass) yapılandırarak Z prime bozonunun değişmez kütle grafiğini çizdirdik.
- ROOT programında bir macro aracılığıyla sinyal ve ardalan üst üste çizdirdik.
- Elde ettiğimiz sinyal grafiğinin makaledeki sonuçla şekil olarak uyumlu olduğunu gördük.

TEŞEKKÜRLER