CutLang ile Analiz Çalışmaları ve Uygulamaları

O. Cakir

Ankara, Şubat 2020

Uygulama

ATLAS Open Data - bazı MC örneklemleri

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_147770.Zee.root	*Zee* + Jets	21-Jul-2016 16:00	966,1Mb	7500000
	mc_147771.Zmumu.root	*Zμμ* + Jets	21-Jul-2016 16:00	946,4Mb	7500000
	mc_147772.Ztautau.root	*Zττ* + Jets	21-Jul-2016 16:00	95,8Mb	750000
	mc_117049.ttbar_had.root	*tt* → Jets	21-Jul-2016 16:00	5,8Mb	25170
	mc_117050.ttbar_lep.root	*tt* → *l* + X	21-Jul-2016 16:00	300,1Mb	1500000
	mc_173041.DYeeM08to15.root	Drell-Yan *ee* with M_{ee}[08-15] GeV	21-Jul-2016 16:00	58,2Mb	400000
	mc_173042.DYeeM15to40.root	Drell-Yan *ee* with M_{ee}[15-40] GeV	21-Jul-2016 16:00	102,2Mb	750000
	mc_173043.DYmumuM08to15.root	Drell-Yan *μμ* with $M_{\mu\mu}$[08-15] GeV	21-Jul-2016 16:00	76,1Mb	500000
	mc_173044.DYmumuM15to40.root	Drell-Yan *μμ* with $M_{\mu\mu}$[15-40] GeV	21-Jul-2016 16:00	105,9Mb	750000
	mc_173045.DYtautauM08to15.root	Drell-Yan *ττ* with $M_{\tau\tau}$[08-15] GeV	21-Jul-2016 16:00	1,5Mb	9993
	mc_173046.DYtautauM15to40.root	Drell-Yan *ττ* with $M_{\tau\tau}$[15-40] GeV	21-Jul-2016 16:00	4,6Mb	32393

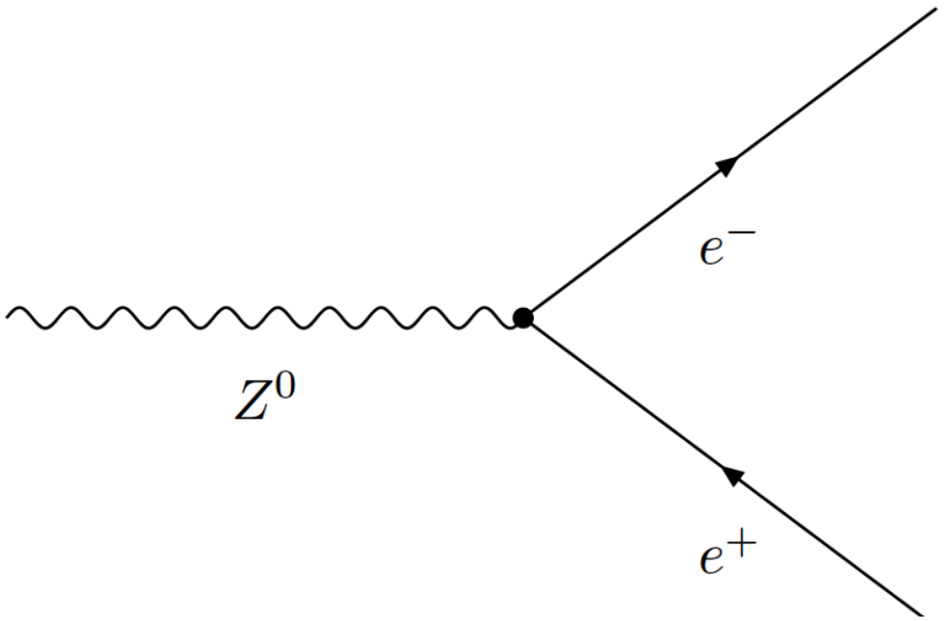
Öğrenme Hedefleri

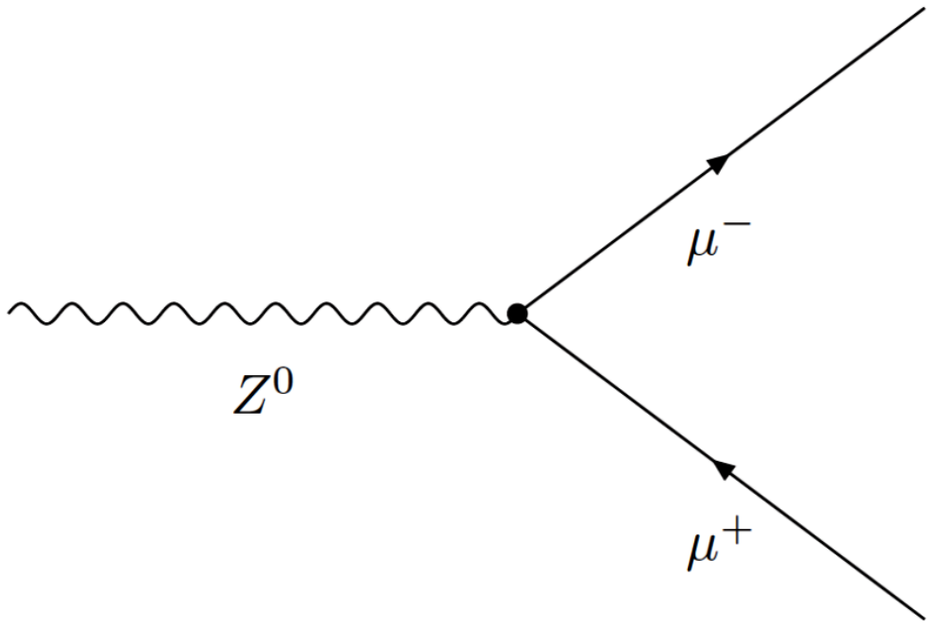
- O1: süreç pp—>Z—>ee
  - Z yapılandırma
- O2: süreç pp—>Z—>mumu
  - Z kütle ölçümü, Z->ll dallanma oranı
- O3: süreç pp—>ZZ—>ee mumu
  - Z1, Z2 yapılandırma
- O4: süreç pp—>W—>mu nu (W-leptonik)
  - W yapılandırma

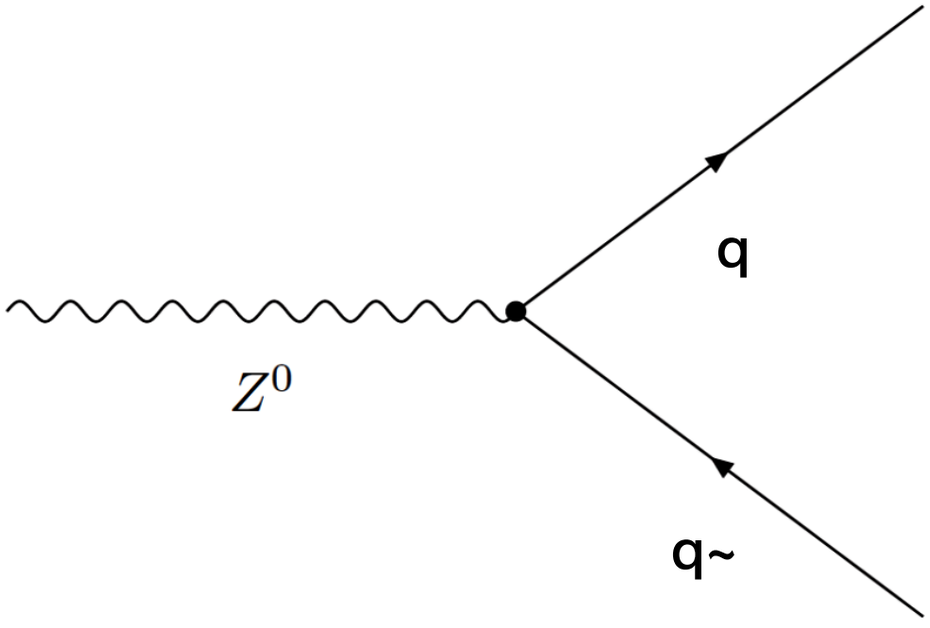
Öğrenme Hedefleri

- O5: süreç pp—>WW—>munu jj (W1-leptonik, W2-hadronik)
    - W1-leptonik, W2-hadronik yapılandırma
- O6: süreç pp—>tt~—>WbWb—>(full hadronik)
    - Hadronik modda üst kuarkların yeniden yapılandırılması

Süreçler







O1.adl

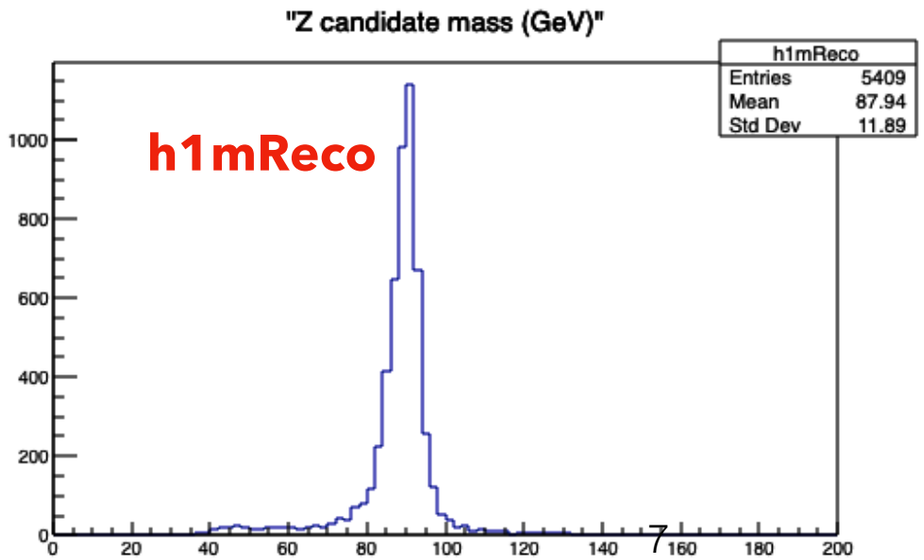
```
Efficiencies for analysis : BP_1
                                                    test    Based on 10000 events:
                                                                    ALL :      1 +-         0 evt:    10000
                                                            Size (ELE) >= 2 : 0.5409 +-   0.00498 evt:     5409
                                                [Histo] Z candidate mass (GeV) :      1 +-         0 evt:     5409
                                                       {ELE[0] ELE[1] }q == 0 : 0.9763 +-   0.00207 evt:     5281
                                                [Histo] Z candidate mass (GeV) :      1 +-         0 evt:     5281
                                                    --> Overall efficiency  =   52.8 % +-  0.499 %
saving...       saved.
finished.
```

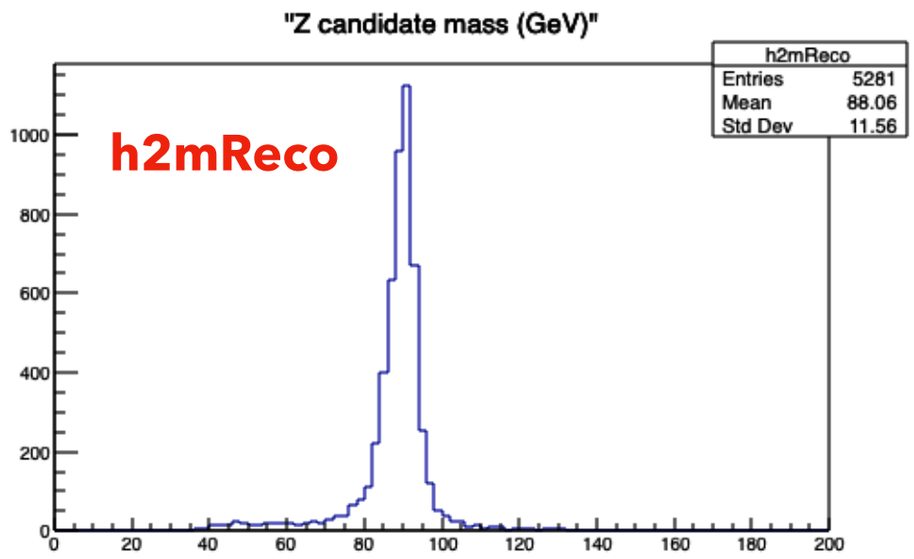
ATLAS open data: mc_147770.Zee.root

```
region   test
  select      ALL              # to count all events
  select      Size (ELE) >= 2  # events with 2 or more electrons
  histo       h1mReco, "Z candidate mass (GeV)", 100, 0, 200, {ELE_0 ELE_1}m
  select      {ELE[0] ELE[1] }q == 0   # Z is neutral
  histo       h2mReco, "Z candidate mass (GeV)", 100, 0, 200, {ELE_0 ELE_1}m
```

```
./CLA.sh  ../Input/MC/mc_147770.Zee.root  ATLASOD  -i  O1.adl  -e  10000
```

histoOut-O1.root





O2.adl

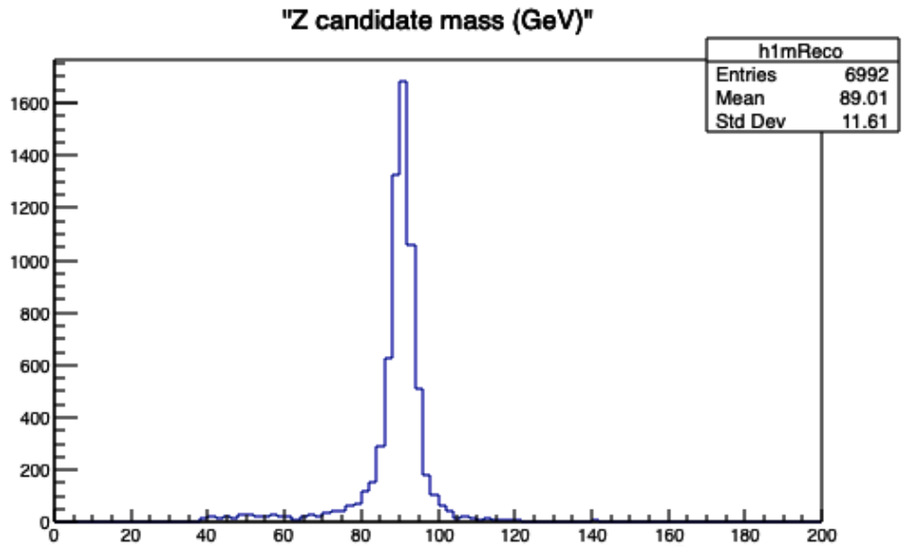
```
Efficiencies for analysis : BP_1
                                                    test    Based on 10000 events:
                                                                    ALL :      1 +-          0 evt:    10000
                                                          Size (MUO) >= 2 : 0.6992 +-    0.00459 evt:     6992
                                        [Histo] Z candidate mass (GeV) :      1 +-          0 evt:     6992
                                               {MUO[0] MUO[1] }q == 0 : 0.9986 +-   0.000452 evt:     6982
                                        [Histo] Z candidate mass (GeV) :      1 +-          0 evt:     6982
                                             --> Overall efficiency  =   69.8 % +-   0.459 %
saving...       saved.
finished.
```

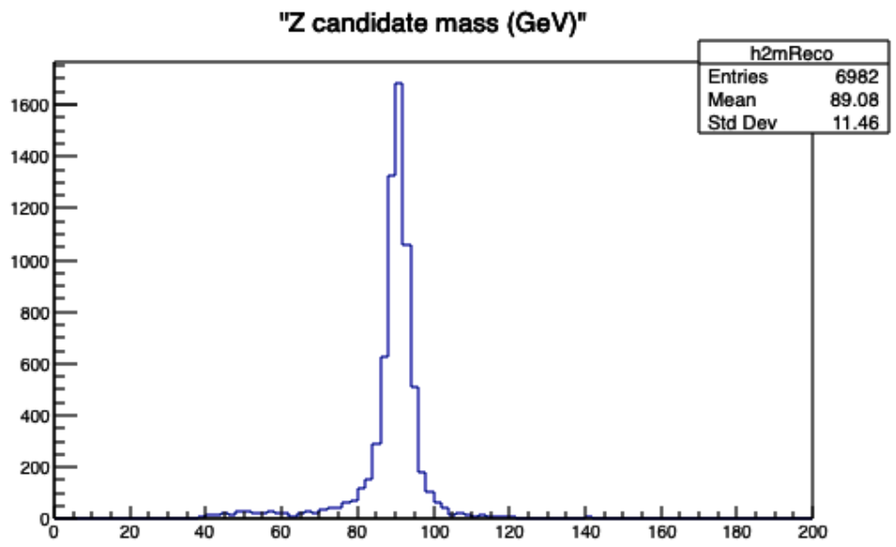
ATLAS open data:
mc_147771.Zmumu.root

region test
  select ALL # to count all events
  select Size (MUO) >= 2 # events with 2 or more muons
  histo h1mReco, "Z candidate mass (GeV)", 100, 0, 200, {MUO_0 MUO_1}m
  select {MUO[0] MUO[1] }q == 0 # Z is neutral
  histo h2mReco, "Z candidate mass (GeV)", 100, 0, 200, {MUO_0 MUO_1}m

```
./CLA.sh ../Input/MC/mc_147771.Zmumu.root ATLASOD -i O2.adl -e 10000
```

histoOut-O2.root





O3.adl

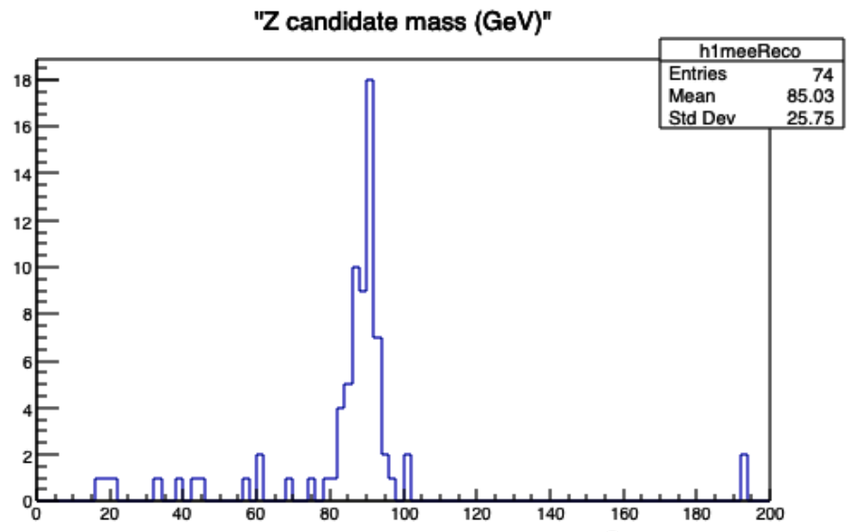
```
Efficiencies for analysis : BP_1
                                                    test    Based on 10000 events:
                                                                    ALL :      1 +-          0 evt:     10000
                                                       Size (ELE) >= 2 : 0.2903 +-    0.00454 evt:      2903
                                                       Size (MUO) >= 2 : 0.02652 +-    0.00298 evt:        77
                  {ELE[0] ELE[1] }q == 0 AND {MUO[0] MUO[1] }q == 0 :  0.961 +-     0.0221 evt:        74
                                        [Histo] Z candidate mass (GeV) :      1 +-          0 evt:        74
                                        [Histo] Z candidate mass (GeV) :      1 +-          0 evt:        74
                                             --> Overall efficiency  =   0.74 % +- 0.0857 %
saving...       saved.
finished.
```

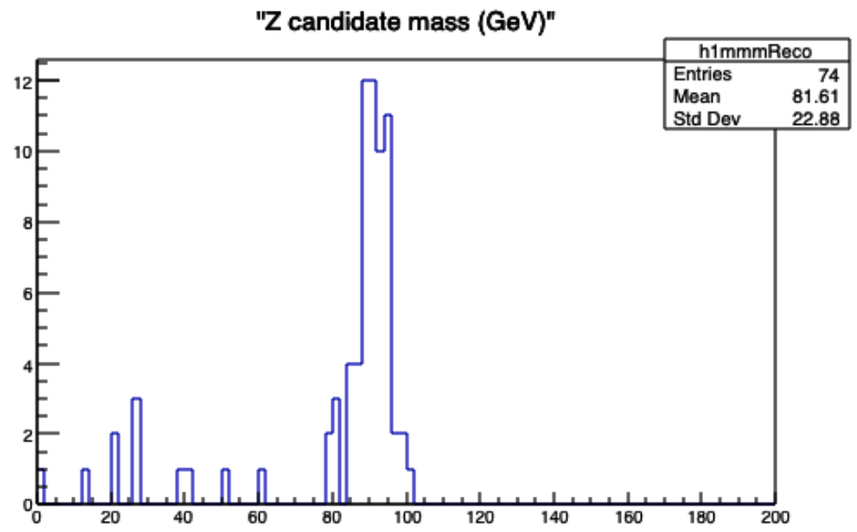
ATLAS open data:
mc_105986.ZZ.root

```
region   tes
  select      ALL              # to count all events
  select      Size (ELE) >= 2  # events with 2 or more electrons
  select      Size (MUO) >= 2  # events with 2 or more muons
  select      {ELE[0] ELE[1] }q == 0 AND {MUO[0] MUO[1] }q == 0   # both Z are neutral
  histo       h1meeReco, "Z candidate mass (GeV)", 100, 0, 200, {ELO_0 ELE_1}m
  histo       h2mmmReco, "Z candidate mass (GeV)", 100, 0, 200, {MUO_0 MUO_1}m
```

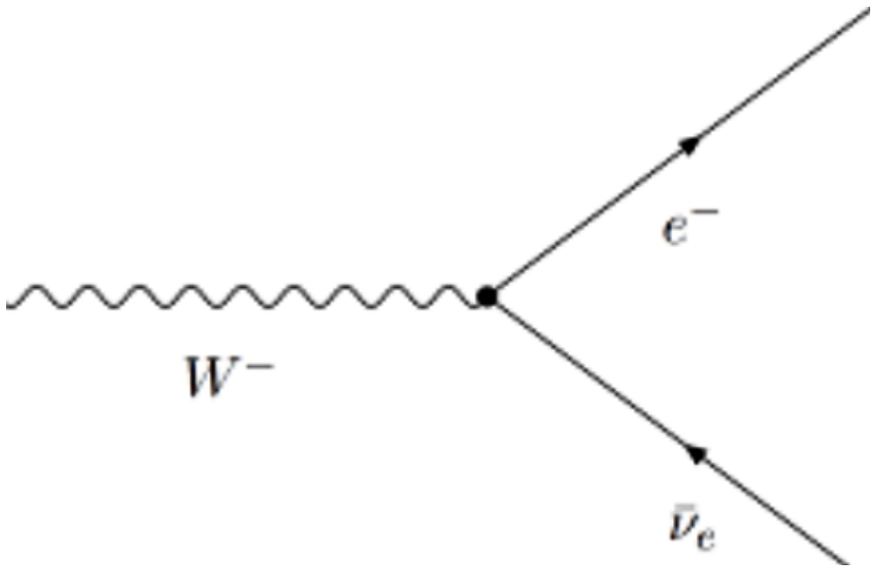
```
./CLA.sh  ../Input/MC/mc_105986.ZZ.root   ATLASOD  -i O3.adl  -e 10000
```

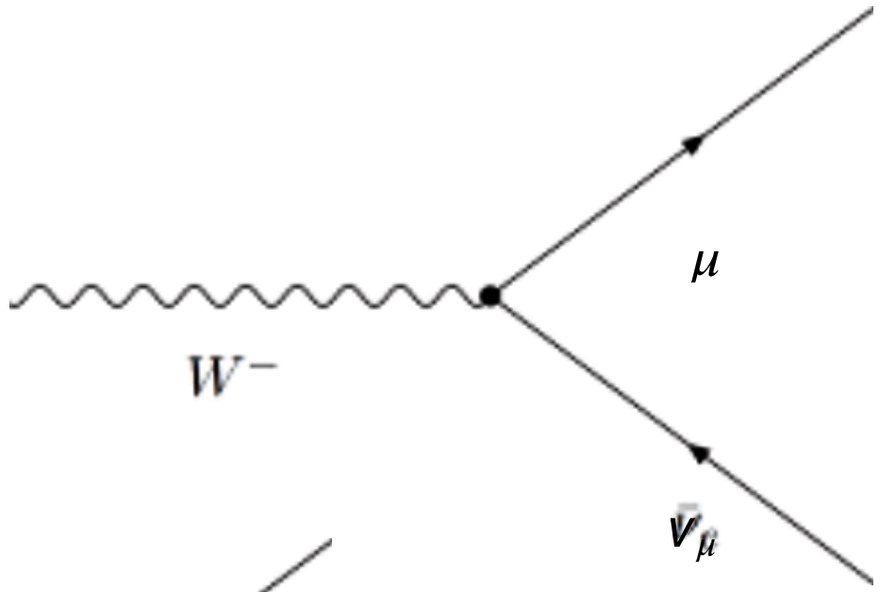
histoOut-O3.root

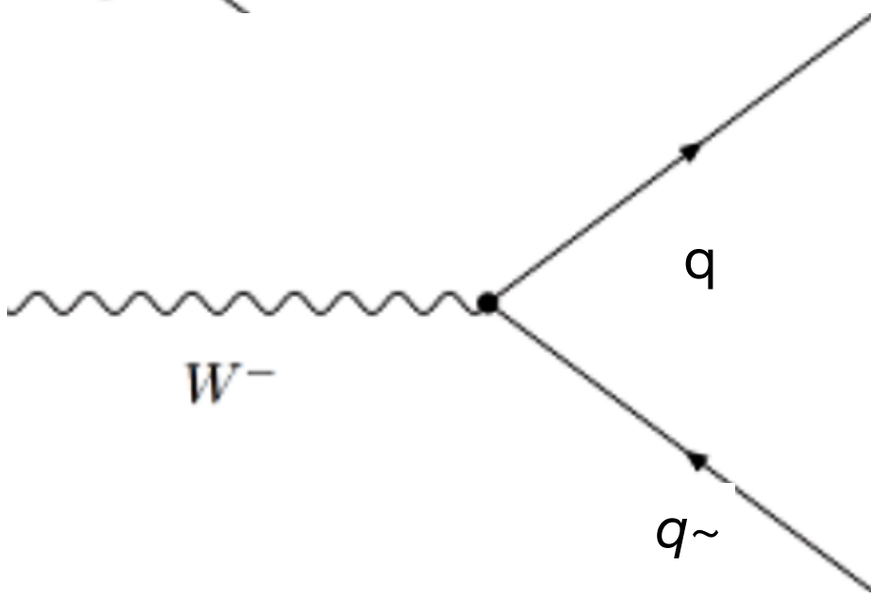




Süreçler







O4.adl

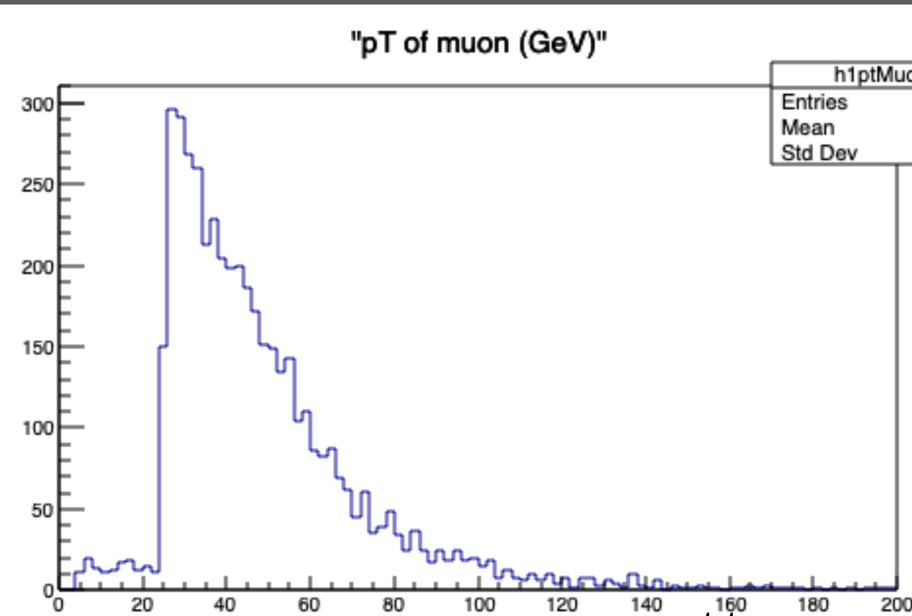
```
Efficiencies for analysis : BP_1
                         test     Based on 10000 events:
                              ALL :        1 +-         0 evt:    10000
                    Size (MUO) >= 1 : 0.5318 +-   0.00499 evt:     5318
                        MET > 20 : 0.8778 +-   0.00449 evt:     4668
          [Histo] pT of muon (GeV) :        1 +-         0 evt:     4668
     [Histo] W candidate mass (GeV) :        1 +-         0 evt:     4668
         --> Overall efficiency  =   46.7 % +-  0.499 %
```

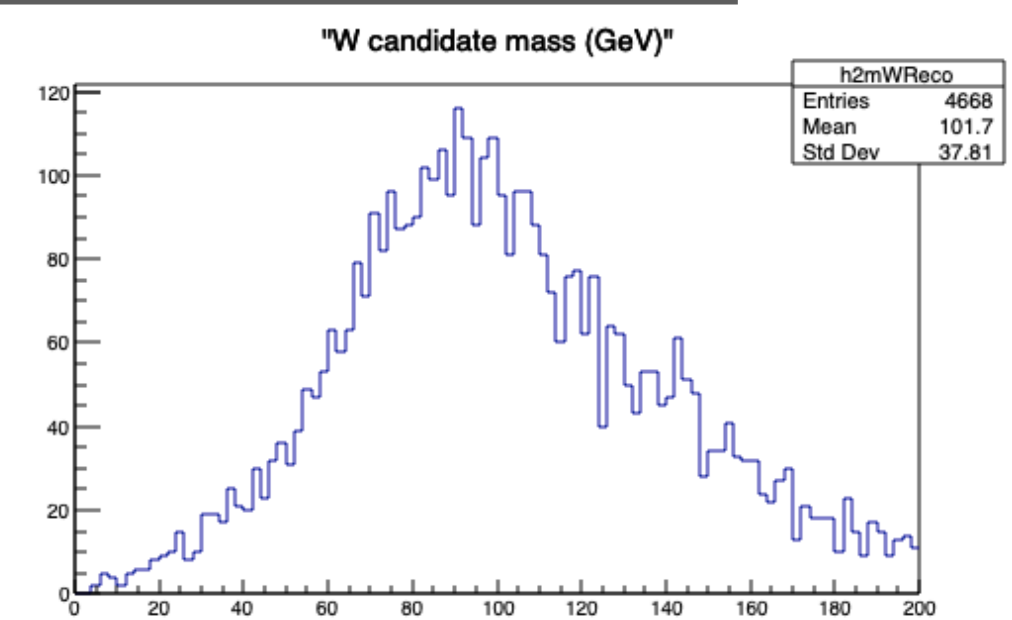
ATLAS open data:
mc_105985.WW.root

```
region   test
  select      ALL              # to count all events
  select      Size (MUO) >= 1  # events with 1 muon or more
  define    Wreco : MUO_0  METLV_0      # definition Wreco
  histo      h1muPt, “pT of muon (GeV)", 100, 0, 200, Pt{MUO_0}
  histo      h2mReco, "W candidate mass (GeV)", 100, 0, 200, {Wreco}m
```

```
./CLA.sh  ../Input/MC/mc_105985.WW.root   ATLASOD  -i O4.adl  -e 10000
```

histoOut-O4.root





O5.adl

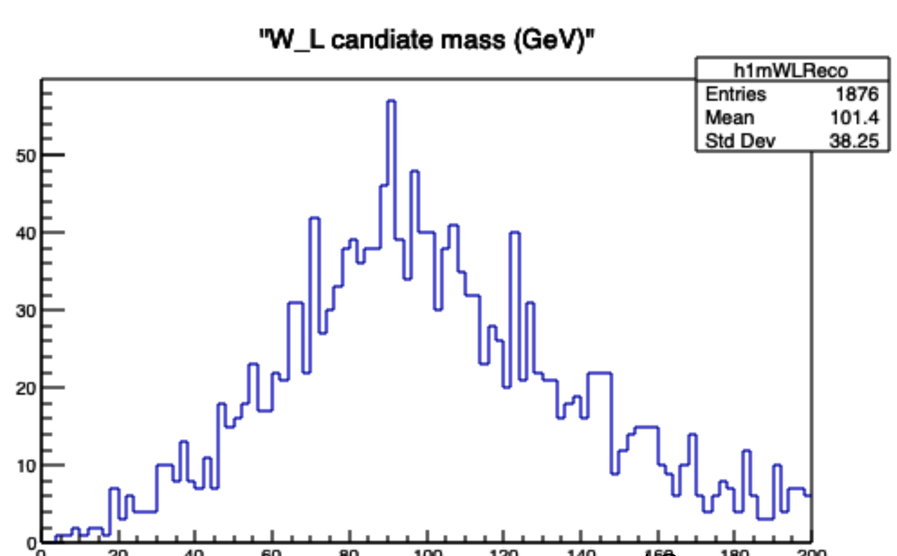
```
Efficiencies for analysis : BP_1
                     test     Based on 10000 events:
                          ALL :       1 +-        0 evt:     10000
              Size (MUO) >= 1 : 0.5318 +-   0.00499 evt:      5318
                     MET > 20 : 0.8778 +-   0.00449 evt:      4668
              Size (JET) >= 2 : 0.4019 +-   0.00718 evt:      1876
 [Histo] W_L candiate mass (GeV) :     1 +-        0 evt:      1876
[Histo] W_H candidate mass (GeV) :     1 +-        0 evt:      1876
      --> Overall efficiency  =  18.8 % +-   0.39 %
```

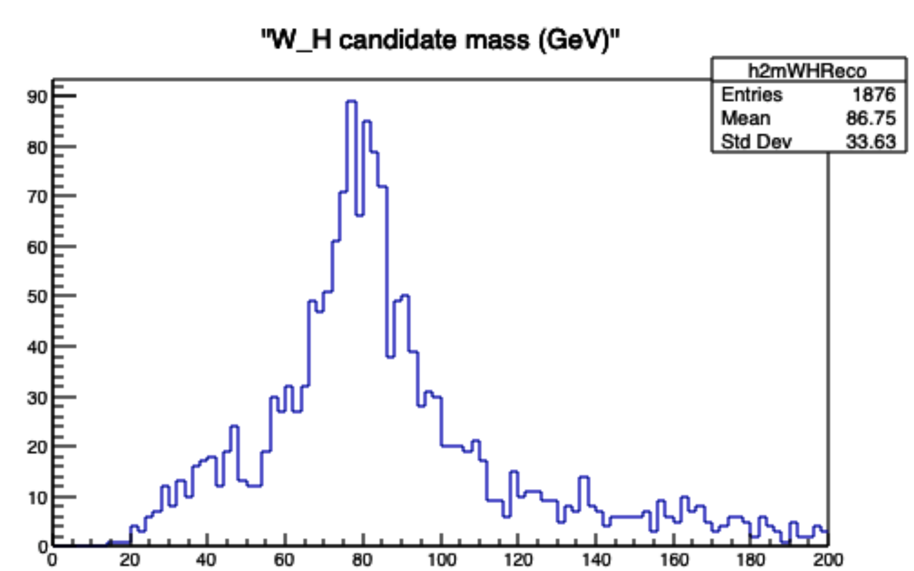
ATLAS open data:
mc_105985.WW.root

```
define    WLreco : MUO_0  METLV_0    #  definition WLreco
define    WHreco : JET_0  JET_1    #  definition WHreco
region   test
 select     ALL            # to count all events
 select     Size (MUO) >= 1  # events with 1 muon or more
 Select     MET > 20   # cut MET > 20 GeV
 select     Size (JET) >= 2  # events with 2 jets or more
 histo      h1mWL, "W_L candidate mass (GeV)", 100, 0, 200, {WLreco}m
 histo      h2mWH, "W_H candidate mass (GeV)", 100, 0, 200, {WHreco}m
```

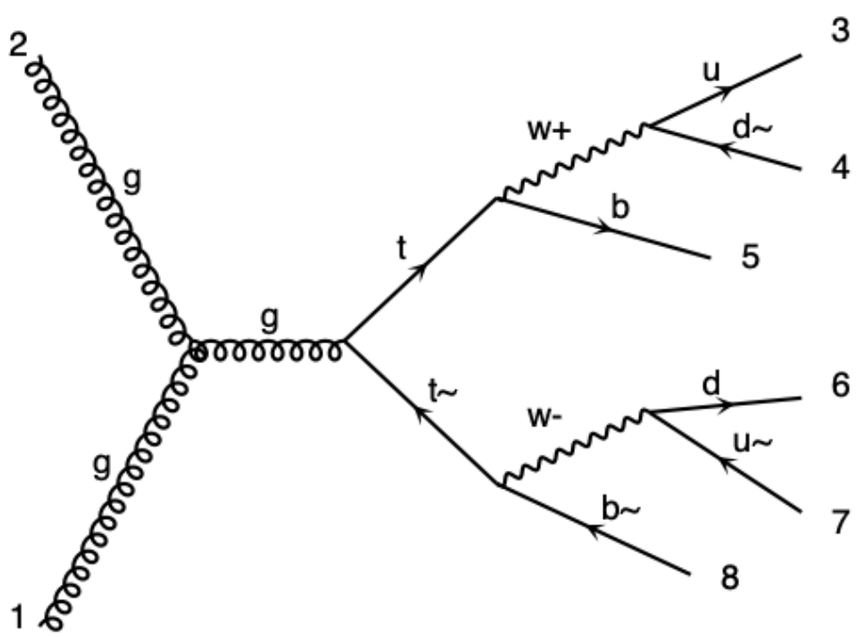
```
./CLA.sh  ../Input/MC/mc_105985.WW.root   ATLASOD  -i O5.adl  -e 10000
```

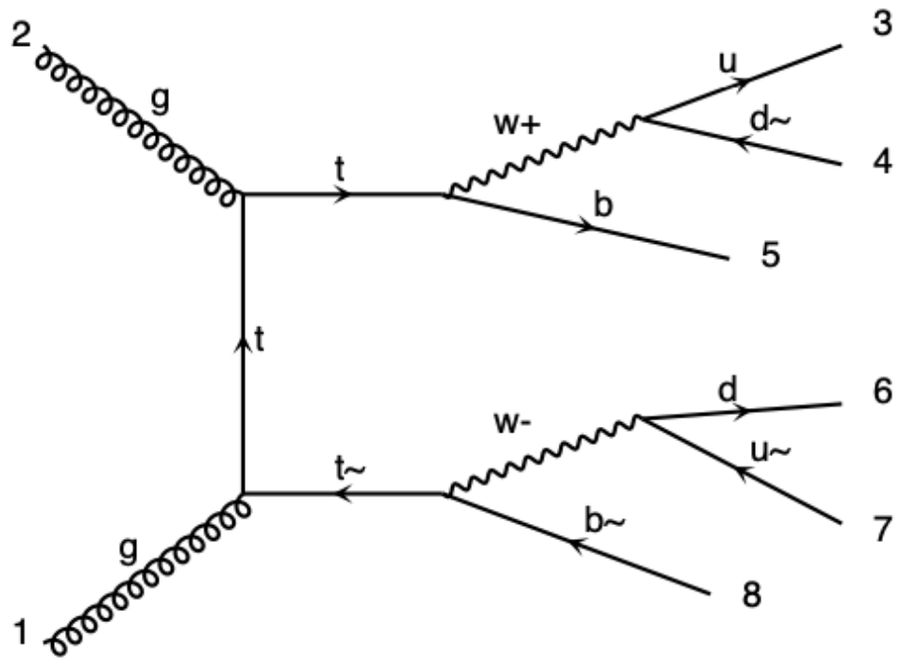
histoOut-O5.root

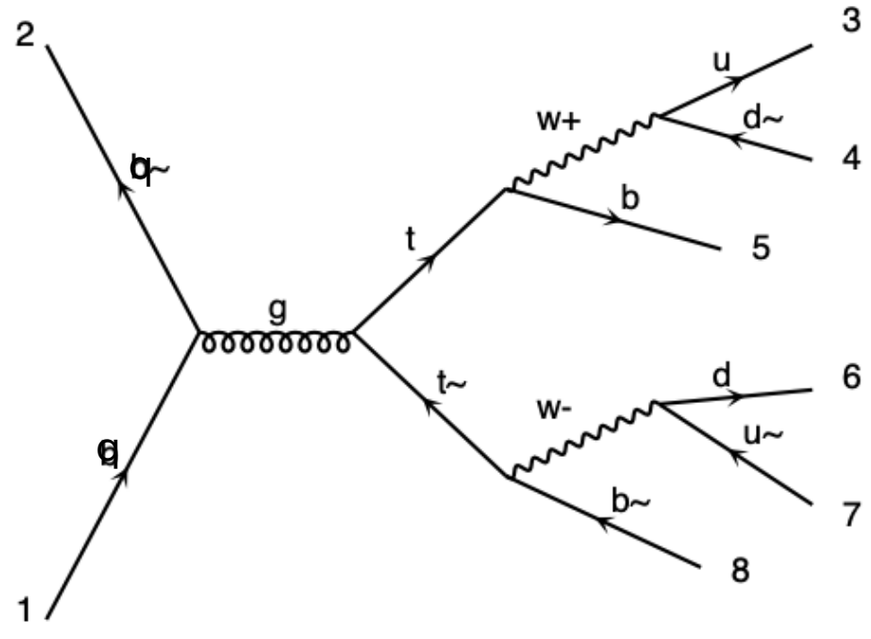




Süreçler


2
g
g
g
1
t
t~
w+
w-
u
d~
d
u~
b
b~
3
4
5
6
7
8


2
g
g
1
t
t
t~
w+
w-
u
d~
d
u~
b
b~
3
4
5
6
7
8


2
q
q
1
g
t
t~
w+
w-
u
d~
d
u~
b
b~
3
4
5
6
7
8

O6.adl (pp->tt~->WWbb->6j)

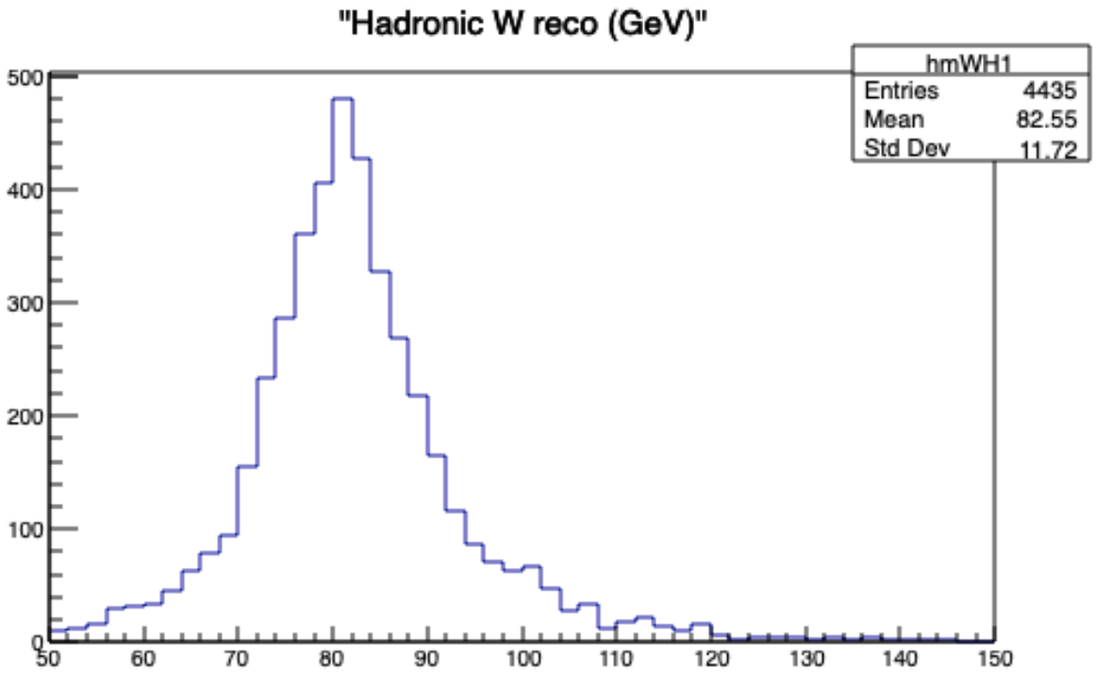
ATLAS open data:
mc_117049.ttbar_had.root

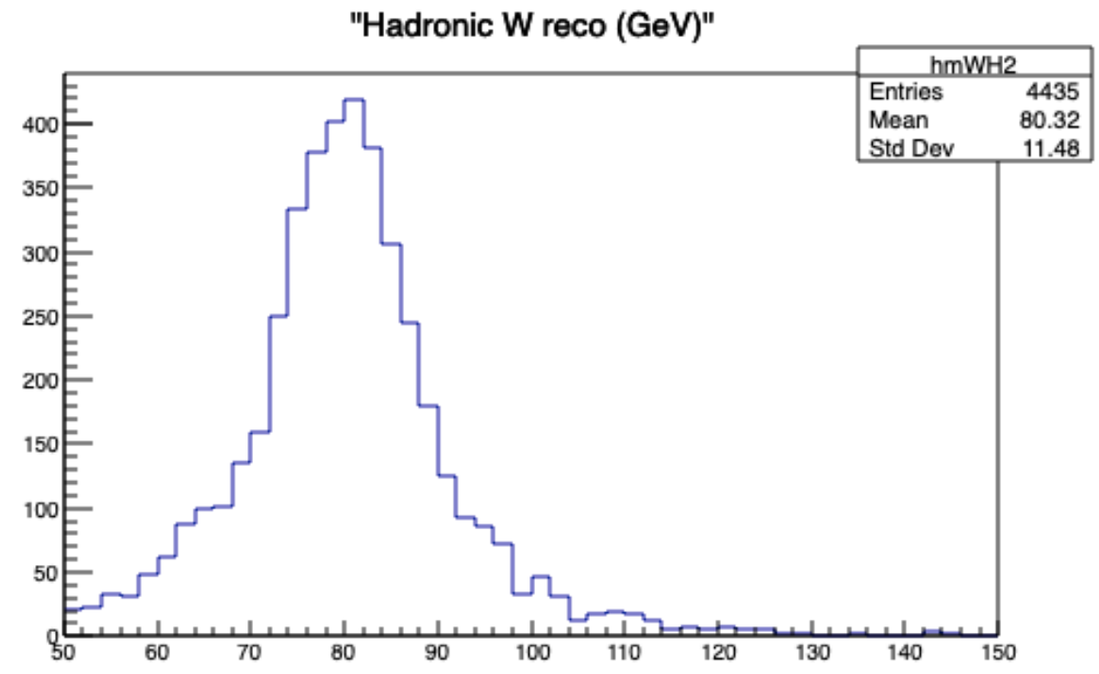
```
#O8.adl
define   WH1  : JET[-1] JET[-1]
define   WH2  : JET[-3] JET[-3]
###      chi2 for W finder
define   Wchi2 : (({WH1}m - 80.4)/2.1)^2 + (({WH2}m - 80.4)/2.1)^2
## top quarks without b tagging
define   Top1 : WH1 JET[-2]
define   Top2 : WH2 JET[-4]
define   mTop1 : m(Top1)
define   mTop2 : m(Top2)
###      chi2 for top finder
define   topchi2 : ((mTop1 - mTop2)/4.2)^2
algo best
 select   ALL                  # to count all events
 select   Size(JET) >= 6        # at least 6 jets
 select   MET < 100             # no large MET
  select    Wchi2 + topchi2 ~= 0   # find the tops and ws
  histo     hmWH1 , "Hadronic W reco (GeV)", 50, 50, 150, m(WH1)
  histo     hmWH2 , "Hadronic W reco (GeV)", 50, 50, 150, m(WH2)
  histo     hmTop1 , "Hadronic top reco (GeV)", 70, 0, 700, mTop1
  histo     hmTop2 , "Hadronic top reco (GeV)", 70, 0, 700, mTop2
```

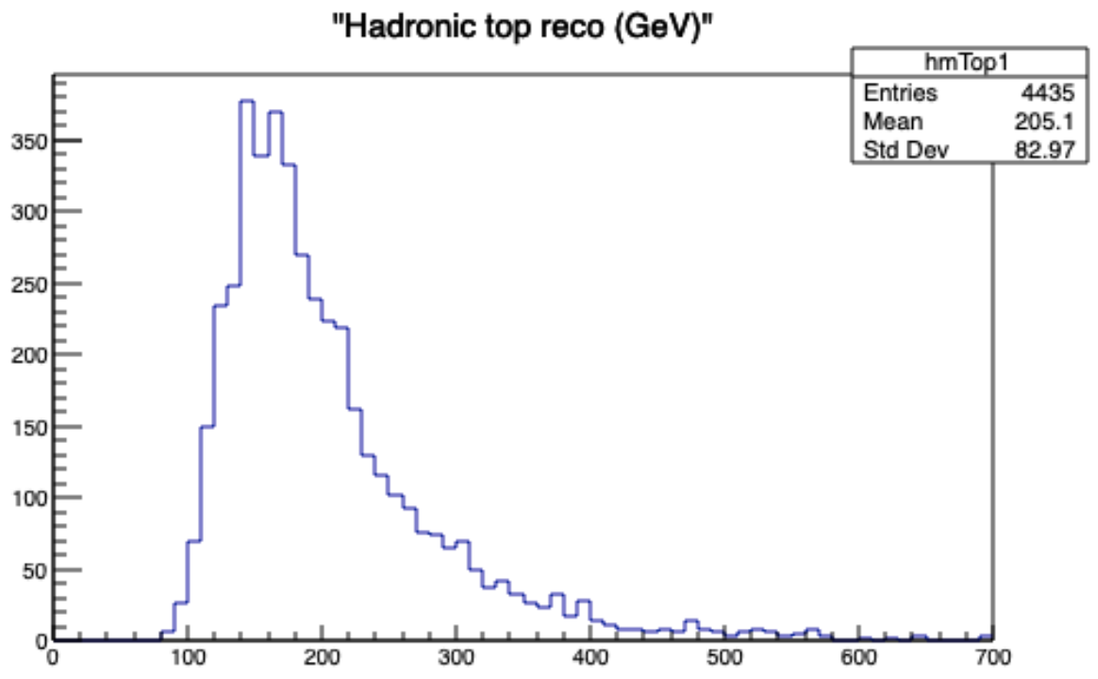
```
Efficiencies for analysis : BP_1
                              best    Based on 20000 events:
                                     ALL :      1 +-        0 evt:    20000
                           Size(JET) >= 6 : 0.2248 +-  0.00295 evt:     4496
                                MET < 100 : 0.9864 +-  0.00173 evt:     4435
                     Wchi2 + topchi2 ~= 0 :      1 +-        0 evt:     4435
             [Histo] Hadronic W reco (GeV) :      1 +-        0 evt:     4435
             [Histo] Hadronic W reco (GeV) :      1 +-        0 evt:     4435
           [Histo] Hadronic top reco (GeV) :      1 +-        0 evt:     4435
           [Histo] Hadronic top reco (GeV) :      1 +-        0 evt:     4435
                  --> Overall efficiency  =   22.2 % +-  0.294 %
```

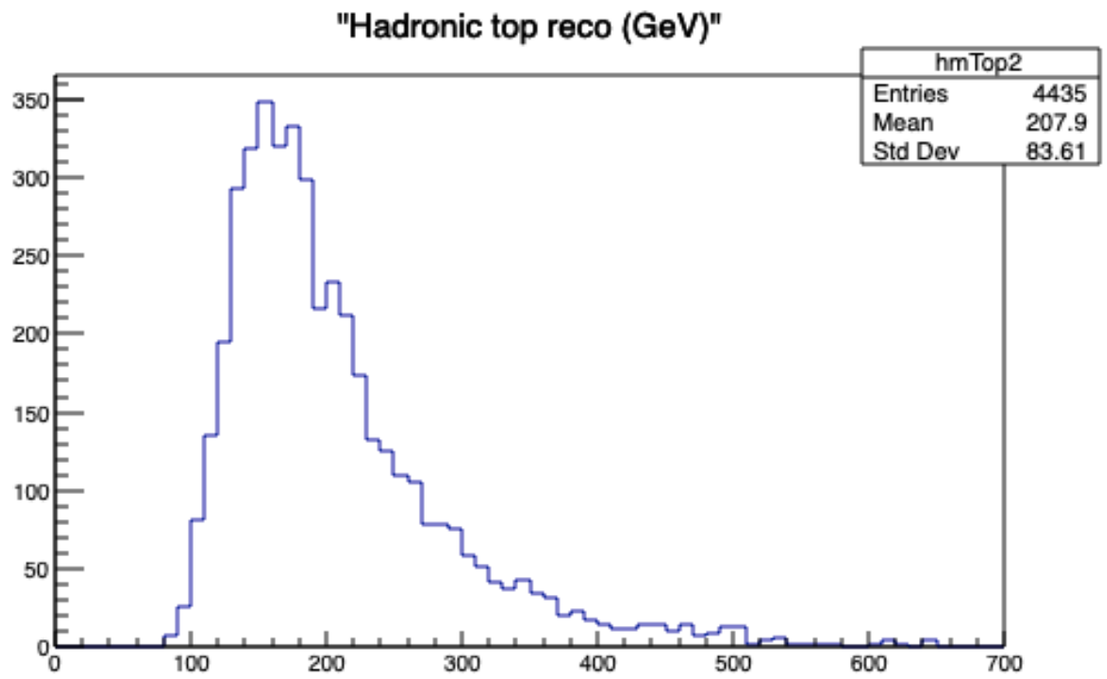
```
./CLA.sh  ../Input/MC/mc_117049.ttbar_had.root   ATLASOD  -i O6.adl  -e 20000
```

O6.adl - Histogramlar









Ek-1

- CutLang ile analiz sonucu oluşan, örneğin “histoOut-abc.root” dosyalarından Root makroları yardımıyla histogram çizilmesi

```
{
TFile* infile1 = new TFile(“histoOut-abc.root","READ");
//
infile1->cd();
//
TH1* sh=(TH1*)infile1->Get("best/hmTop1");
//
Double_t norm1 = sh->GetEntries();
sh->Scale(1/norm1);
sh->SetLineColor(kRed);
//
sh->Draw("H");
```

Myplot.C

Kaynaklar

- G. Unel, S. Sekmen, *CutLang:* A Particle Physics Analysis Description Language and Runtime Interpreter, Comp. Phys. Comm. Volume 233, December 2018, Pages 215-236.
- ATLAS Collaboration, Measurement of the $t\bar{t}$ production cross-section using eμ events with b-tagged jets in pp collisions at $\sqrt{s}$ = 13 TeV with the ATLAS detector, Phys. Lett. B761 (2016) 136, [hep-ex/1606.02699].
- Pavol Bartoš for the ATLAS Collaboration, Top quark pair-production cross-section measurements with the ATLAS detector, PoS(DIS2018)122.
- Till Arndt for CMS Collaboration, Measurement of the top quark pair production cross section at 13 TeV with the CMS detector, PoS(TOP2015)026.
- CMS Collaboration, Measurement of the tt production cross section in the dilepton channel in pp collisions at $\sqrt{s}$ = 8 TeV, JHEP02(2014)024.