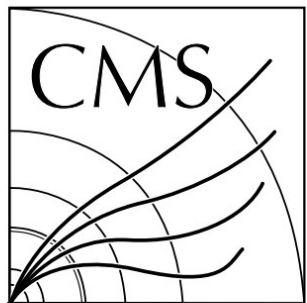


**Search for supersymmetry in multijet events  
with missing transverse momentum in proton-  
proton collisions at 13 TeV**



CMS-SUS-16-033

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Ömer Faruk Kadı  
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# Giriş

- Makale
- Yaptıklarımız
- Sonuçlar

# Makale

- p-p çarpışması – 13 TeV
- CERN BHC-(LHC) CMS Algıcı 2016 yılında yayınlı
- Integrated luminosity of 35.9 fb<sup>-1</sup>

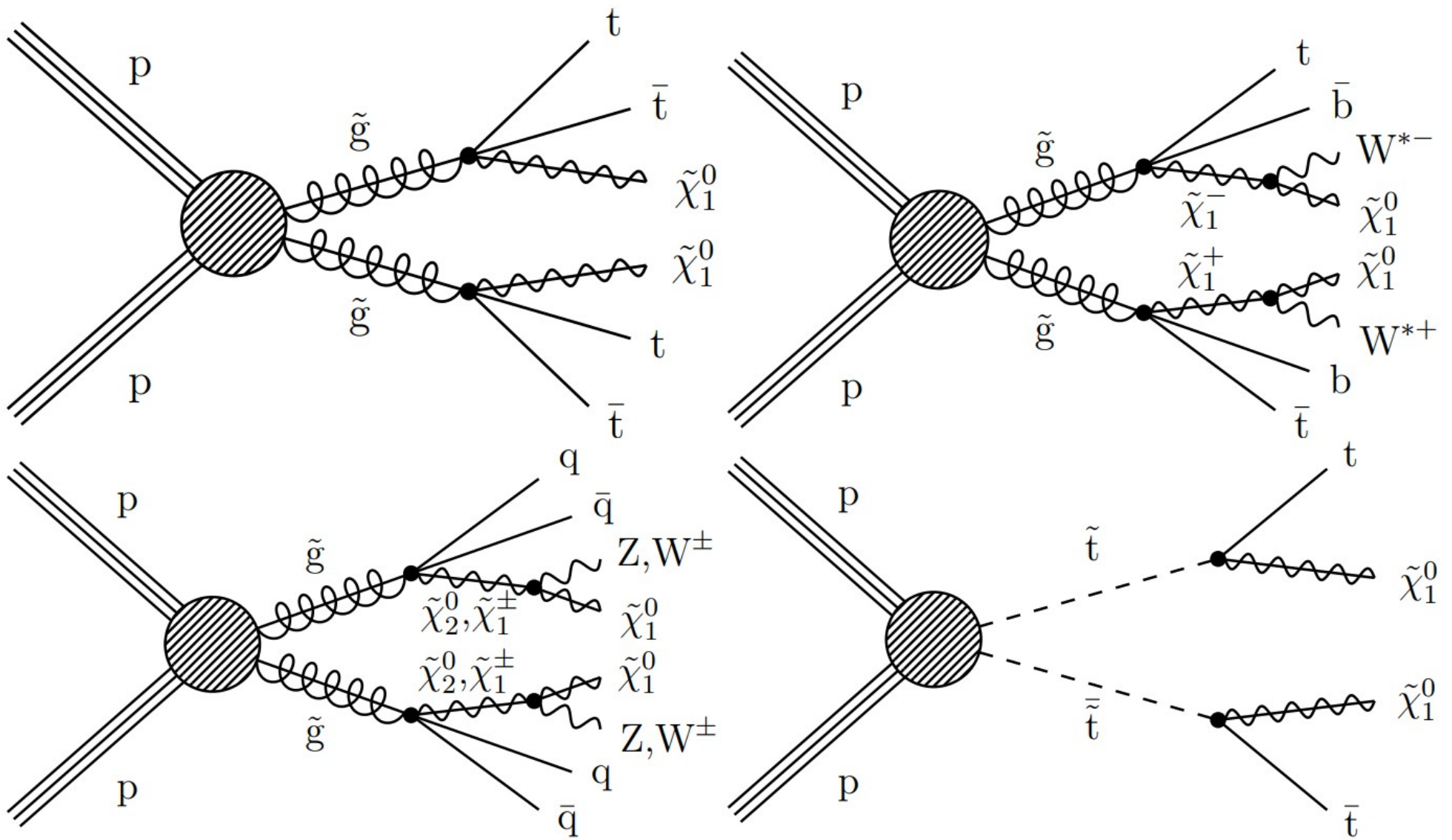


CERN-EP-2017-072  
2017/09/01

Published in Physical Review D as doi:10.1103/PhysRevD.96.032003.

# SM'in ötesinde

- Squarklar, gluinolar, neutrolinolar
- Gözlemlenmemiş LSPLer (en hafif supersimetrik parçacık)
- Karanlık madde



Şekilde: Basitleştirilmiş Feynman Diagramları  
 (Üst Sol) T1ttt, (Üst Sağ) T1btb, (Alt Sol) T5qqqqVV, (Alt Sağ) T2tt

# Biz ne yaptık?

```
1 object goodJET : JET
2   select AbsEta(JET_) < 2.4
3   select pt(JET_) > 30
4
5 object goodELE : ELE
6   select pt(ELE_) > 10
7   select AbsEta(ELE) < 2.5
8
9 object jetsmht : JET
10  select AbsEta(JET_) < 2.4
11  select pt(JET_) > 30
12
13 object goodMUO : MUO
14  select AbsEta(MUO) < 2.4
15  select pt(MUO_) > 10
16
17 define MHTLV = sum(jetsmht)
18 define MHT = pt(MHTLV)
19
```

```
20 region PreSelect
21   select ALL
22   select Size(goodJET)>=2
23   select Size(jetsmht) >= 0
24   histo bHT, "Before HT cut", 250,0,4000, HT(goodJET)
25   select HT(goodJET) >= 300
26   histo bMHT, "Before MHT cut", 250,0,4000, HT(goodJET)
27   select MHT >= 300
28   histo aMHT, "After MHT cut", 250,0,4000, HT(goodJET)
29   select Size(goodELE) == 0
30   select Size(goodMUO) == 0
31   select dphi(METLV[0], goodJET[0]) > 0.5
32   select dphi(METLV[0], goodJET[1]) > 0.5
33   histo aps, "After PreSelect", 250, 0, 4000, HT(goodJET)
34
```

# • Kodumuz:

```
object goodJET : JET
  select AbsEta(JET_) < 2.4
  select pt(JET_) > 30
```

```
object goodELE : ELE
  select pt(ELE_) > 10
  select AbsEta(ELE) < 2.5
```

```
object jetsmht : JET
  select AbsEta(JET_) < 2.4
  select pt(JET_) > 30
```

```
object goodMUO : MUO
  select AbsEta(MUO) < 2.4
  select pt(MUO_) > 10
```

```
define MHTLV = sum(jetsmht)
define MHT = pt(MHTLV)
```

```
region PreSelect
  select ALL
  select Size(goodJET)>=2
  select Size(jetsmht) >= 0
  histo bHT, "Before HT cut", 250,0,4000, HT(goodJET)
  select HT(goodJET) >= 300
  histo bMHT, "Before MHT cut", 250,0,4000, HT(goodJET)
  select MHT >= 300
  histo aMHT, "After MHT cut", 250,0,4000, HT(goodJET)
  select Size(goodELE) == 0
  select Size(goodMUO) == 0
  select dphi(METLV[0], goodJET[0]) > 0.5
  select dphi(METLV[0], goodJET[1]) > 0.5
  histo aps, "After PreSelect", 250, 0, 4000, HT(goodJET)
```

```
region bin1
#number 1
  PreSelect
  select Size(BJET) == 0
  select HT(goodJET) >= 500
  select MHT >= 500
  histo hbin1, "After bin1 cut", 250,0,4000, HT(goodJET)
```

```
region bin2
#number 3
  PreSelect
  select Size(goodJET)>= 5
  select Size(BJET) == 0
  select HT(goodJET) >= 500
  select MHT >= 500
  select dphi(METLV[0], goodJET[2]) > 0.3
  select dphi(METLV[0], goodJET[3]) > 0.3
  histo hbin2, "After bin2 cut", 250,0,4000, HT(goodJET)
```

```
region bin3
#number 6
  PreSelect
  select Size(goodJET)>= 2
  select Size(BJET) == 2
  select HT(goodJET) >= 500
  select MHT >= 500
  histo hbin3, "After bin3 cut", 250,0,4000, HT(goodJET)
```

```
region bin4
#number 4
  PreSelect
  select Size(goodJET)>= 5
  select Size(BJET) == 0
  select HT(goodJET) >= 1500
  select MHT >= 750
  select dphi(METLV[0], goodJET[2]) > 0.3
  select dphi(METLV[0], goodJET[3]) > 0.3
  histo hbin3, "After bin3 cut", 250,0,4000, HT(goodJET)
```



# PreSelect

Selection	pp $\rightarrow \tilde{g}\tilde{g}, \tilde{g} \rightarrow t\bar{t}\tilde{\chi}_1^0$ $m_{\tilde{g}} = 1500 \text{ GeV}$ $m_{\tilde{\chi}_1^0} = 100 \text{ GeV}$
$N_{\text{jet}} \geq 2$	$100.0 \pm 0.0$
$H_T > 300 \text{ GeV}$	$100.0 \pm 0.0$
$H_T^{\text{miss}} > 300 \text{ GeV}$	$76.7 \pm 0.3$
$N_{\text{muon}} = 0$	$48.6 \pm 0.4$
$N_{\text{isolated tracks}}^{(\text{muon})} = 0$	$47.8 \pm 0.4$
$N_{\text{electron}} = 0$	$30.7 \pm 0.3$
$N_{\text{isolated tracks}}^{(\text{electron})} = 0$	$29.7 \pm 0.3$
$N_{\text{isolated tracks}}^{(\text{hadron})} = 0$	$28.3 \pm 0.3$
$\Delta\phi_{H_T^{\text{miss}}, j_1} > 0.5$	$27.7 \pm 0.3$
$\Delta\phi_{H_T^{\text{miss}}, j_2} > 0.5$	$25.2 \pm 0.3$
$\Delta\phi_{H_T^{\text{miss}}, j_3} > 0.3$	$23.7 \pm 0.3$
$\Delta\phi_{H_T^{\text{miss}}, j_4} > 0.3$	$22.1 \pm 0.3$
Event quality filter	$21.8 \pm 0.3$

```

PreSelect          Based on 20000
                   ALL :          1 +-
                   Size(goodJET)>=2 : 1 +-
                   Size(jetsmht) >= 0 : 1 +-
                   [Histo] Before HT cut : 1 +-
                   HT(goodJET) >= 300 : 0.9996 +-
                   [Histo] Before MHT cut : 1 +-
                   MHT >= 300 : 0.7651 +-
                   [Histo] After MHT cut : 1 +-
                   Size(goodELE) == 0 : 0.8448 +-
                   Size(goodMUO) == 0 : 0.7829 +-
                   dphi(METLV[0], goodJET[0]) > 0.5 : 0.9816 +-
                   dphi(METLV[0], goodJET[1]) > 0.5 : 0.8889 +-
                   [Histo] After PreSelect : 1 +-
                   --> Overall efficiency = 44.1 % +-

```

Selection	$pp \rightarrow \tilde{g}\tilde{g}, \tilde{g} \rightarrow t\bar{t}\tilde{\chi}_1^0$ $m_{\tilde{g}} = 1200 \text{ GeV}$ $m_{\tilde{\chi}_1^0} = 800 \text{ GeV}$
$N_{\text{jet}} \geq 2$	$100.0 \pm 0.0$
$H_T > 300 \text{ GeV}$	$99.0 \pm 0.0$
$H_T^{\text{miss}} > 300 \text{ GeV}$	$14.9 \pm 0.1$
$N_{\text{muon}} = 0$	$9.6 \pm 0.1$
$N_{\text{isolated tracks}}^{(\text{muon})} = 0$	$9.2 \pm 0.1$
$N_{\text{electron}} = 0$	$6.2 \pm 0.1$
$N_{\text{isolated tracks}}^{(\text{electron})} = 0$	$5.8 \pm 0.1$
$N_{\text{isolated tracks}}^{(\text{hadron})} = 0$	$5.3 \pm 0.1$
$\Delta\phi_{H_T^{\text{miss}}, j_1} > 0.5$	$5.3 \pm 0.1$
$\Delta\phi_{H_T^{\text{miss}}, j_2} > 0.5$	$4.5 \pm 0.1$
$\Delta\phi_{H_T^{\text{miss}}, j_3} > 0.3$	$4.0 \pm 0.1$
$\Delta\phi_{H_T^{\text{miss}}, j_4} > 0.3$	$3.6 \pm 0.1$
Event quality filter	$3.5 \pm 0.1$

PreSelect	Based on 20000
ALL :	1 +-
Size(goodJET)>=2 :	1 +-
Size(jetsmht) >= 0 :	1 +-
[Histo] Before HT cut :	1 +-
HT(goodJET) >= 300 :	0.9879 +-
[Histo] Before MHT cut :	1 +-
MHT >= 300 :	0.17 +-
[Histo] After MHT cut :	1 +-
Size(goodELE) == 0 :	0.8207 +-
Size(goodMU0) == 0 :	0.7616 +-
dphi(METLV[0], goodJET[0]) > 0.5 :	0.9952 +-
dphi(METLV[0], goodJET[1]) > 0.5 :	0.855 +-
[Histo] After PreSelect :	1 +-
--> Overall efficiency =	8.93 % +-



Selection	$pp \rightarrow \tilde{t}\tilde{t}, \tilde{t} \rightarrow t\tilde{\chi}_1^0$ $m_{\tilde{t}} = 700 \text{ GeV}$ $m_{\tilde{\chi}_1^0} = 50 \text{ GeV}$
$N_{\text{jet}} \geq 2$	$99.8 \pm 0.0$
$H_T > 300 \text{ GeV}$	$96.4 \pm 0.1$
$H_T^{\text{miss}} > 300 \text{ GeV}$	$57.8 \pm 0.3$
$N_{\text{muon}} = 0$	$46.6 \pm 0.3$
$N_{\text{isolated tracks}}^{(\text{muon})} = 0$	$46.1 \pm 0.3$
$N_{\text{electron}} = 0$	$37.4 \pm 0.3$
$N_{\text{isolated tracks}}^{(\text{electron})} = 0$	$36.9 \pm 0.3$
$N_{\text{isolated tracks}}^{(\text{hadron})} = 0$	$35.8 \pm 0.3$
$\Delta\phi_{H_T^{\text{miss}}, j_1} > 0.5$	$35.7 \pm 0.3$
$\Delta\phi_{H_T^{\text{miss}}, j_2} > 0.5$	$34.0 \pm 0.3$
$\Delta\phi_{H_T^{\text{miss}}, j_3} > 0.3$	$33.1 \pm 0.3$
$\Delta\phi_{H_T^{\text{miss}}, j_4} > 0.3$	$31.8 \pm 0.3$
Event quality filter	$31.4 \pm 0.3$

PreSelect	Based on 20000
ALL :	1 +-
Size(goodJET)>=2 :	0.9918 +-
Size(jetsmht) >= 0 :	1 +-
[Histo] Before HT cut :	1 +-
HT(goodJET) >= 300 :	0.9497 +-
[Histo] Before MHT cut :	1 +-
MHT >= 300 :	0.5906 +-
[Histo] After MHT cut :	1 +-
Size(goodELE) == 0 :	0.9171 +-
Size(goodMU0) == 0 :	0.8731 +-
dphi(METLV[0], goodJET[0]) > 0.5 :	0.9979 +-
dphi(METLV[0], goodJET[1]) > 0.5 :	0.9474 +-
[Histo] After PreSelect :	1 +-
--> Overall efficiency =	42.1 % +-

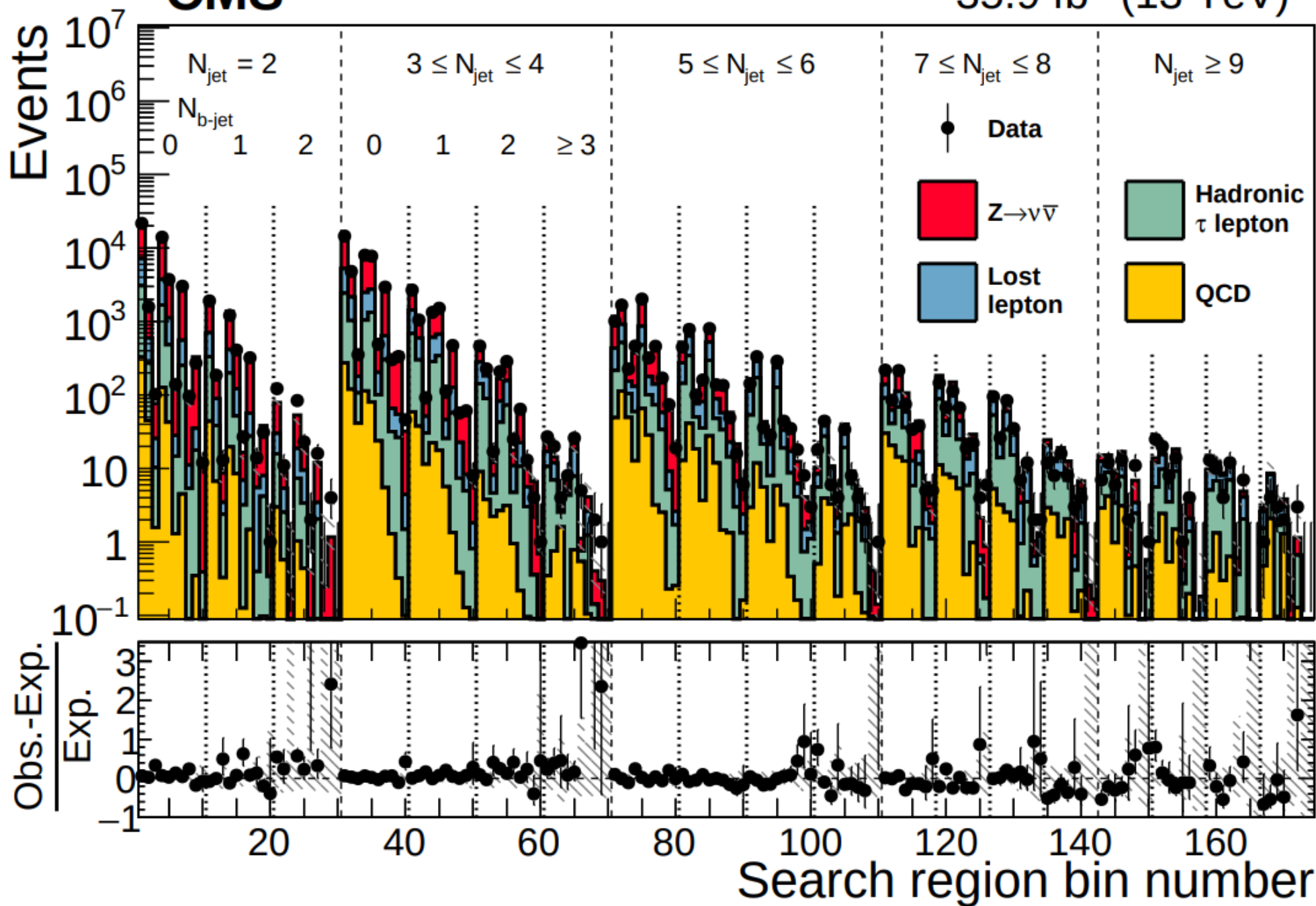
```

PreSelect          Based on 598251 events:
      ALL :          1 +-          0 evt:    598251
      Size(goodJET)>=2 :      1 +-          0 evt:    598251
      Size(jetsmht) >= 0 :      1 +-          0 evt:    598251
[Histo] Before HT cut :      1 +-          0 evt:    598251
      HT(goodJET) >= 300 : 0.4414 +- 0.000642 evt:    264064
[Histo] Before MHT cut :      1 +-          0 evt:    264064
      MHT >= 300 : 0.006873 +- 0.000161 evt:      1815
[Histo] After MHT cut :      1 +-          0 evt:    1815
      Size(goodELE) == 0 : 0.3697 +- 0.0113 evt:      671
      Size(goodMUO) == 0 : 0.4814 +- 0.0193 evt:      323
dphi(METLV[0], goodJET[0]) > 0.5 : 0.9814 +- 0.00751 evt:      317
dphi(METLV[0], goodJET[1]) > 0.5 : 0.858 +- 0.0196 evt:      272
[Histo] After PreSelect :      1 +-          0 evt:    272
--> Overall efficiency = 0.0455 % +- 0.00276 %

```

# CMS

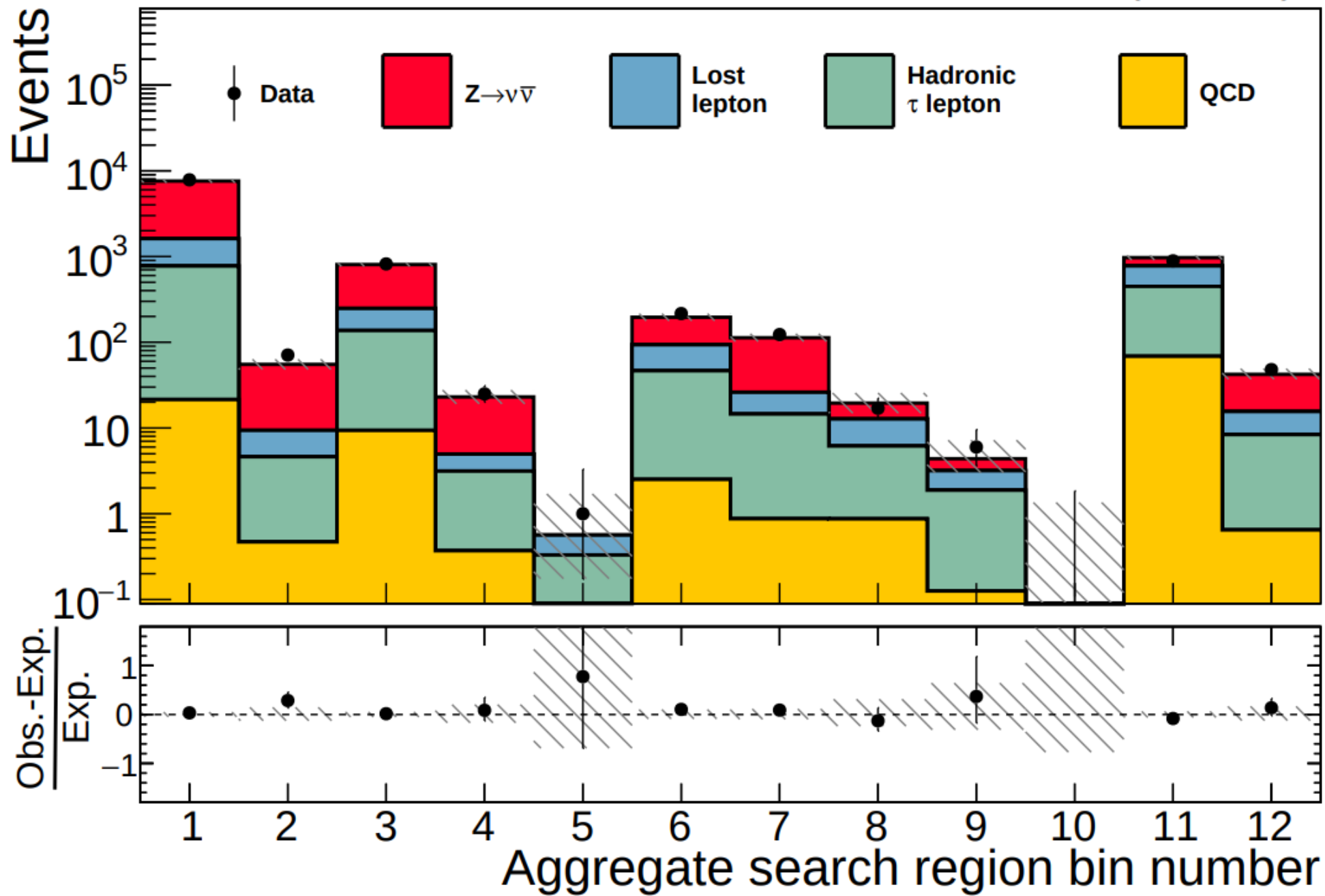
## 35.9 fb<sup>-1</sup> (13 TeV)





# CMS

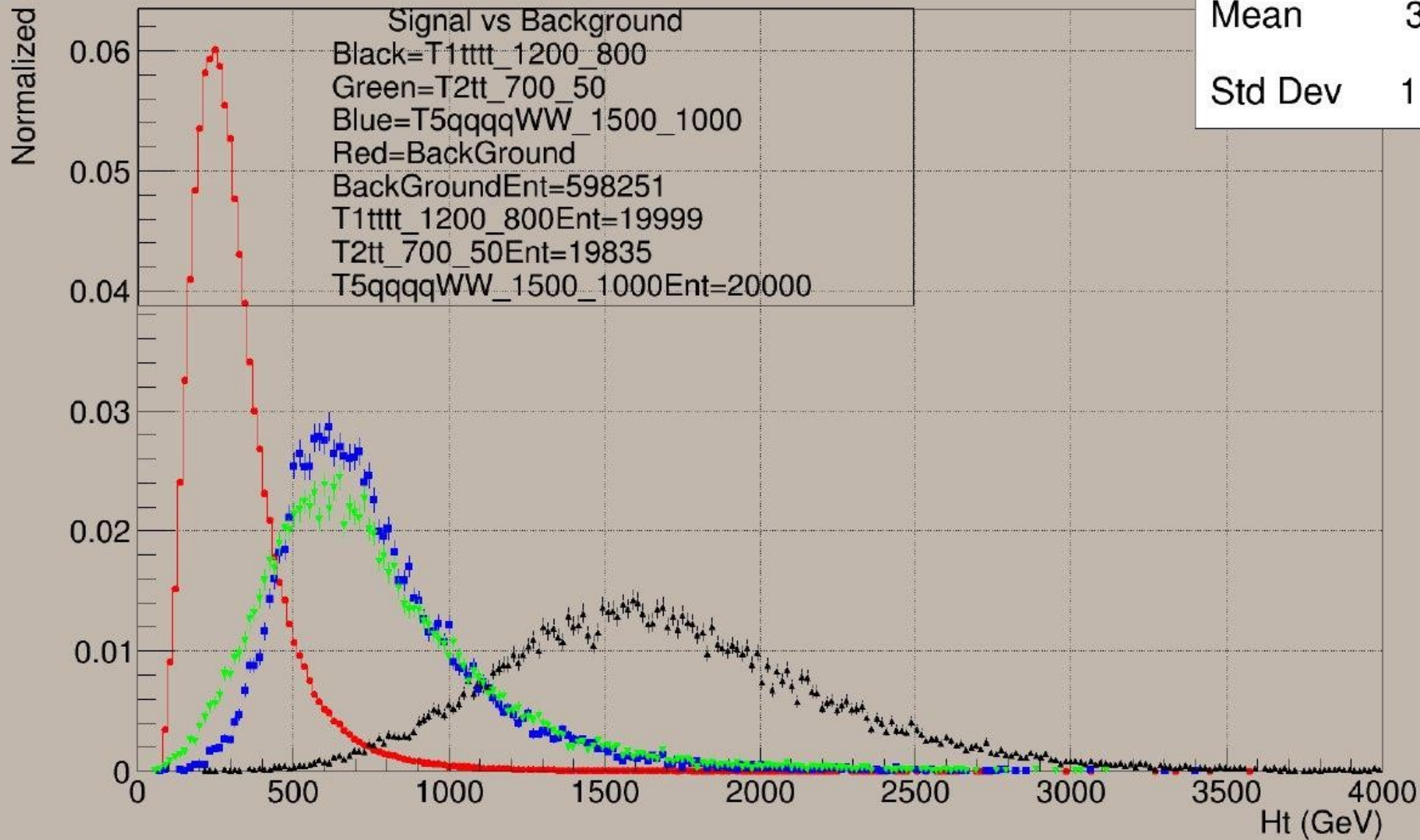
35.9 fb<sup>-1</sup> (13 TeV)



Region	$N_{\text{jet}}$	$N_{\text{b-jet}}$	$H_{\text{T}}$ [GeV]	$H_{\text{T}}^{\text{miss}}$ [GeV]
1	$\geq 2$	0	$\geq 500$	$\geq 500$
2	$\geq 3$	0	$\geq 1500$	$\geq 750$
3	$\geq 5$	0	$\geq 500$	$\geq 500$
4	$\geq 5$	0	$\geq 1500$	$\geq 750$
5	$\geq 9$	0	$\geq 1500$	$\geq 750$
6	$\geq 2$	$\geq 2$	$\geq 500$	$\geq 500$
7	$\geq 3$	$\geq 1$	$\geq 750$	$\geq 750$
8	$\geq 5$	$\geq 3$	$\geq 500$	$\geq 500$
9	$\geq 5$	$\geq 2$	$\geq 1500$	$\geq 750$
10	$\geq 9$	$\geq 3$	$\geq 750$	$\geq 750$
11	$\geq 7$	$\geq 1$	$\geq 300$	$\geq 300$
12	$\geq 5$	$\geq 1$	$\geq 750$	$\geq 750$

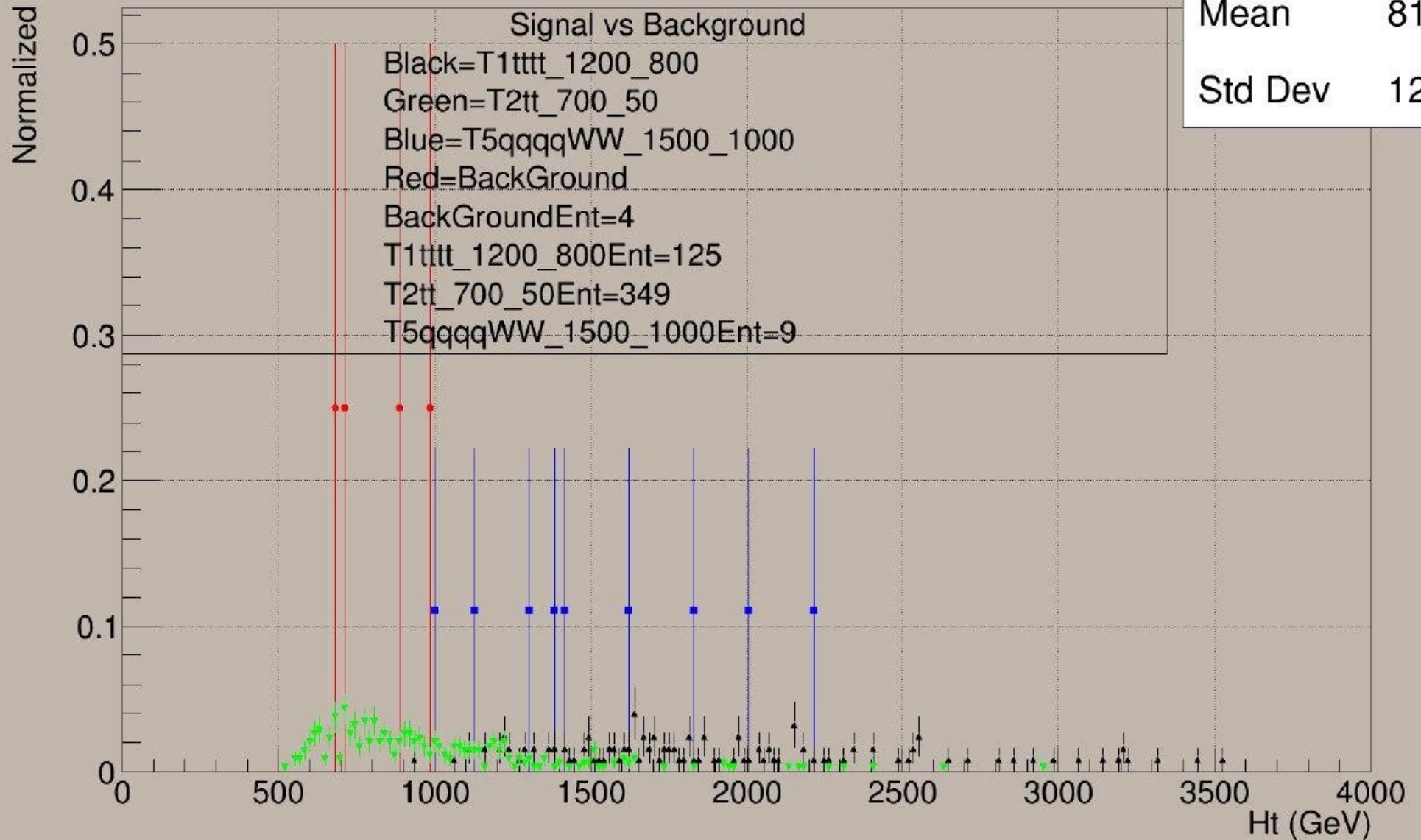
# Grafiklerimiz

Before Preselection

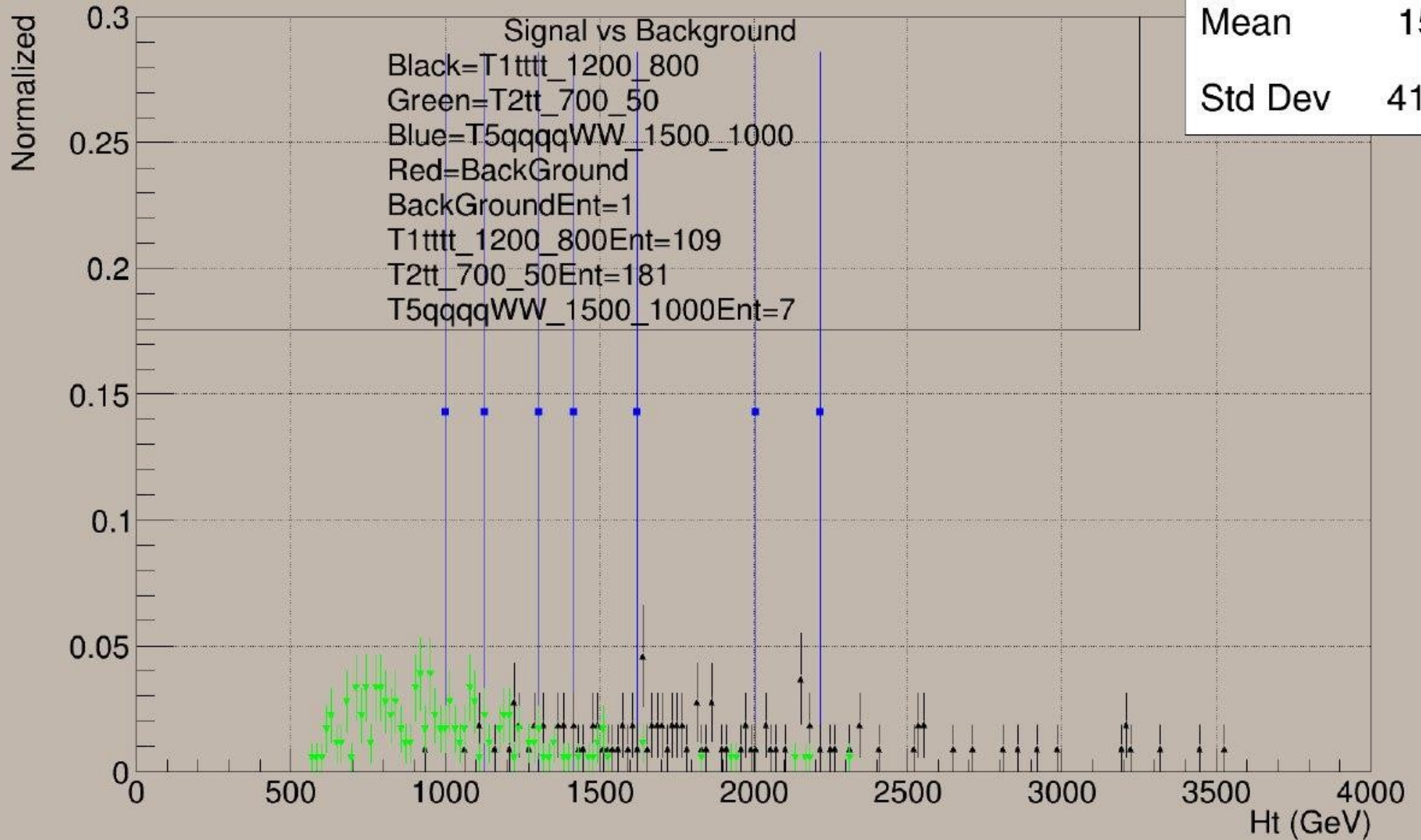




$N_{\text{Jet}} \geq 2$   $N_{\text{b-jet}} = 0$   $H_t > 500$   $HT_{\text{miss}} > 500$

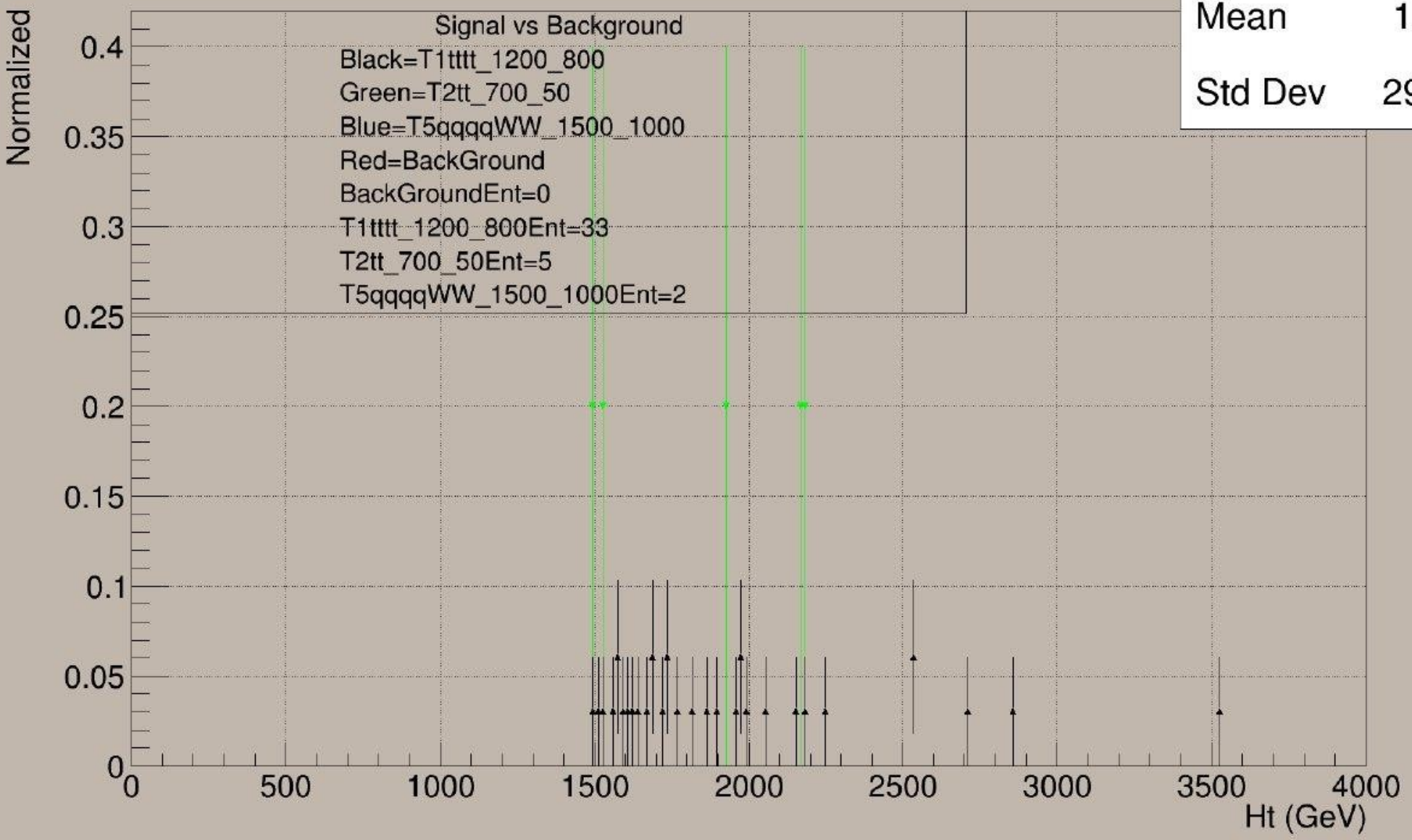


$N_{\text{Jet}} \geq 5$   $N_{\text{b-jet}} = 0$   $H_t > 500$   $HT_{\text{miss}} > 500$



$N_{\text{Jet}} \geq 5$   $N_{\text{b-jet}} \geq 0$   $H_t > 1500$   $HT_{\text{miss}} > 750$

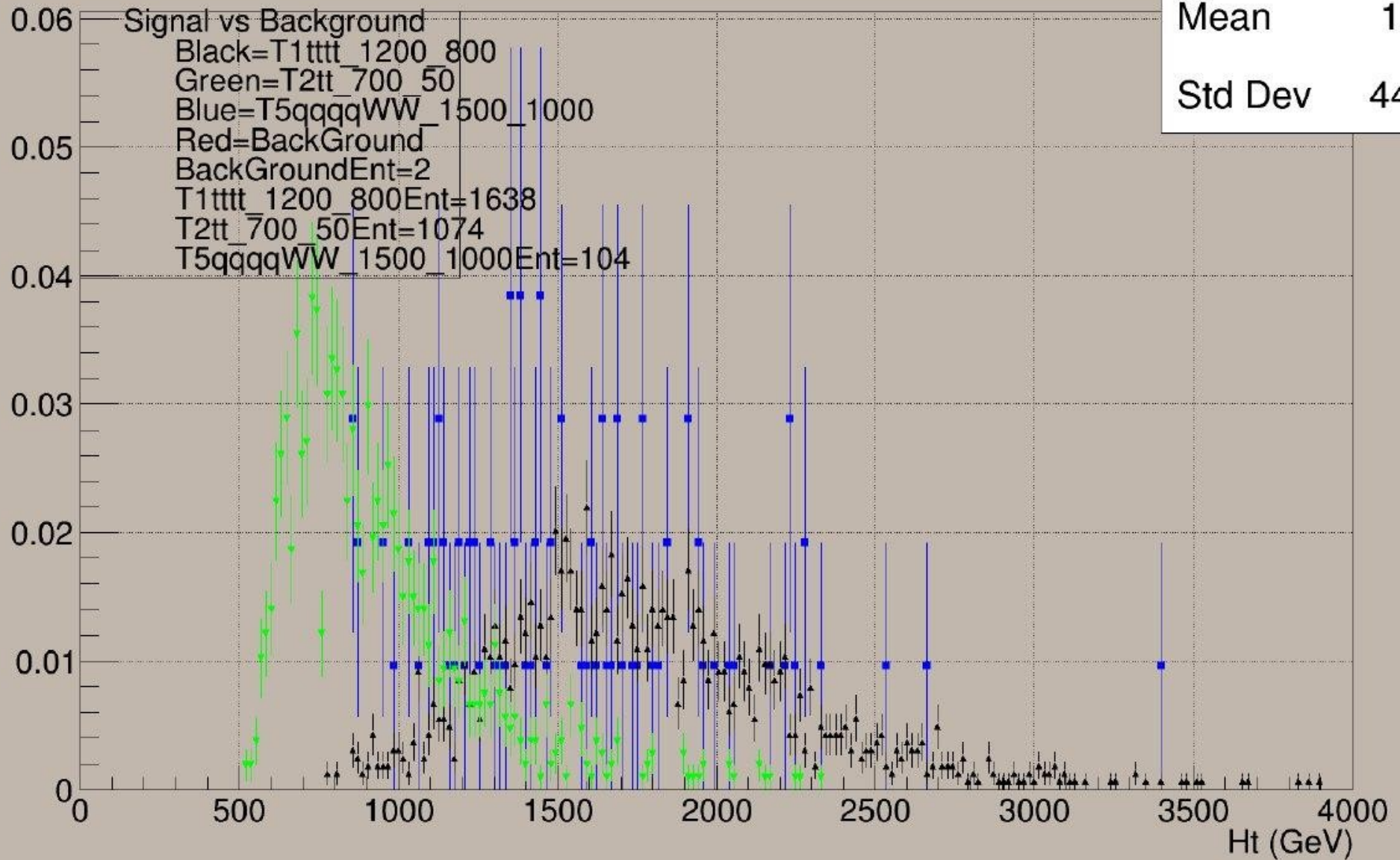
Mean	1866
Std Dev	299.6





$N_{\text{Jet}} \geq 2$   $N_{\text{b-jet}} \geq 2$   $H_t > 500$   $HT_{\text{miss}} > 500$

Normalized



Signal vs Background  
Black=T1ttt\_1200\_800  
Green=T2tt\_700\_50  
Blue=T5qqqqWW\_1500\_1000  
Red=BackGround  
BackGroundEnt=2  
T1ttt\_1200\_800Ent=1638  
T2tt\_700\_50Ent=1074  
T5qqqqWW\_1500\_1000Ent=104

Mean	1542
Std Dev	440.5

# Sonuç:

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Cuma 7.Şubat.2020

# Ama:

- 95% CL ile senaryoya göre :  
gluino kütlesinin 1800 ila 1960 GeV  
squarkların kütleleri 960 ila 1390 GeV

“

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23

Cuma 7.Şubat.2020