# LHeC Two Higgs to 4 bs study

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Bruce Mellado

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# Double Higgs production at the LHeC

| Process | $\sigma$ | $\sigma_{\text{eff}}$ | $N_{Total}^{MC-gen}$ |
|---|---|---|---|
| Sig: | 1.30e-01 | 3.1e-02 | 80000 |
| CCbbbbj: | 2.40e-01 | 6.1e-02 | 240000 |
| CCbbjjj: | 3.34e+03 | 5.0e+01 | 134520 |
| CCzzj($z \to bb\ b$): | 3.40e-01 | 8.7e-02 | 240000 |
| CCttj(hadronic): | 1.08e-01 | 1.5e-04 | 240000 |
| CCttj(lephad): | 4.67e-02 | 1.5e-04 | 240000 |
| NCbbbbj: | 2.30e+04 | 5.8e+01 | 375539 |
| NCbbjjj: | 1.53e+04 | 2.3e+00 | 212154 |
| NCzzj($z \to bb\ b$): | 9.30e-03 | 2.4e-03 | 240000 |
| NCttj(hadronic): | 8.43e+01 | 2.7e-04 | 240000 |
| NCttj(lephad): | 3.27e+01 | 1.9e-04 | 240000 |

Table : Cross sections (in fb): $E_e = 60$ GeV, $E_p = 50$ TeV, $j = gu\ ud\ ds\ sc\ c$. Initial cuts: $|\eta| \leq 10$ for jets, leptons and $b$, $P_T \geq 10$ GeV, $\Delta R_{\min} = 0.6$ for all particles. $\sigma_{eff}$ effective cross sections in fb after multiplying the appropriate rejections factors.

# The cut flows

- Choosing 4b and 1 jet(largest pt excluding the 4b)
- $\eta_{forward} > 4$
- $MET > 50GeV$ and $\Delta\phi_{MET,leadingjet} > 0.7$
- Restrict two masses reconstructed from 4bs to be in 85-125GeV

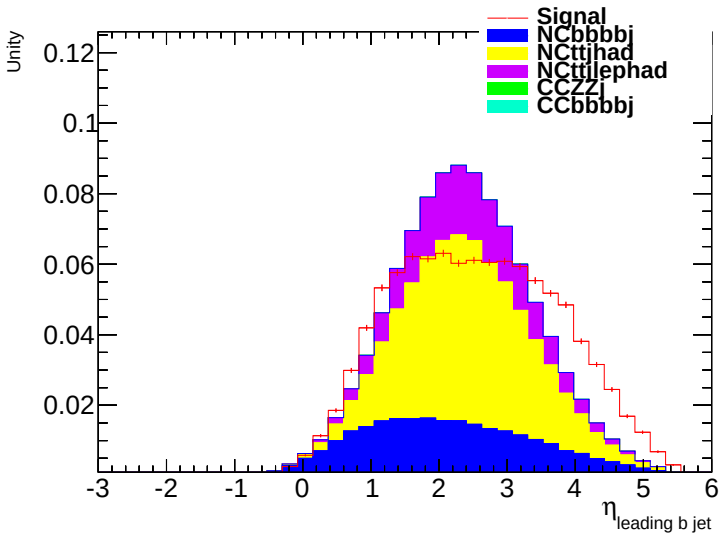
# The cut flows, Events in MC

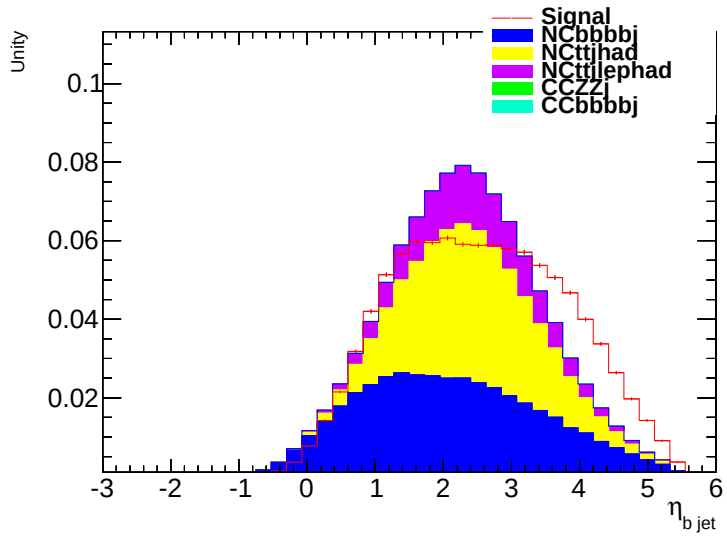
| Samples | Signal | ccbbbbj | ccbbjjj | ncbbbbj | ncbbjjj | ccttjhad | ccttjlephad | ncttjhad | ncttjlephad | cczzj | nczzj | Total bkg | S/Sqrt(B) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| INIT | 80000 | 240000 | 134520 | 375539 | 212154 | 240000 | 240000 | 240000 | 240000 | 240000 | 240000 | 2.40221e+06 | 51.616 |
| 4b1j | 2616 | 1482 | 5 | 256 | 19 | 440 | 175 | 438 | 179 | 6453 | 4871 | 14318 | 21.8623 |
| forward | 1691 | 107 | 0 | 45 | 4 | 29 | 22 | 50 | 27 | 3356 | 1076 | 4716 | 24.6239 |
| MET and $\Delta\phi$ | 872 | 87 | 0 | 2 | 0 | 24 | 18 | 4 | 12 | 2592 | 81 | 2820 | 16.4207 |
| M1M2 | 473 | 9 | 0 | 0 | 0 | 6 | 4 | 0 | 1 | 233 | 7 | 260 | 29.3342 |
| LepRej | 390 | 5 | 0 | 0 | 0 | 5 | 2 | 0 | 1 | 193 | 4 | 210 | 26.9126 |
| M4b | 374 | 5 | 0 | 0 | 0 | 3 | 2 | 0 | 1 | 185 | 4 | 200 | 26.4458 |

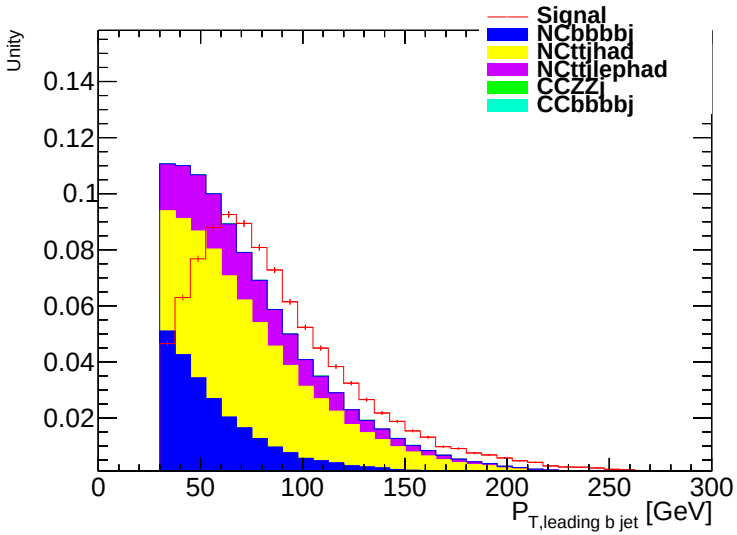
# The cut flows, Weights in MC, $10ab^{-1}$

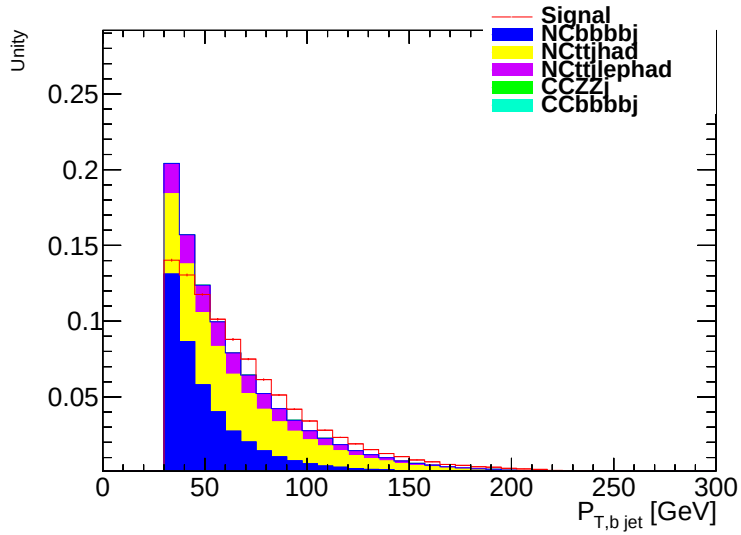
| Samples | Signal | ccbbbbj | ccbbjjj | ncbbbbj | ncbbjjj | ccttjhad | ccttjlephad | ncttjhad | ncttjlephad | cczzj | nczzj | Total bkg | S/Sqrt(B) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| INIT | 2.34e+03 ± 8.27 | 4.32e+03 ± 8.82 | 6.01e+07 ± 1.64e+05 | 4.14e+06 ± 6.76e+03 | 2.75e+08 ± 5.98e+05 | 1.94e+03 ± 3.97 | 841 ± 1.72 | 1.52e+06 ± 3.1e+03 | 5.89e+05 ± 1.2e+03 | 6.12e+03 ± 12.5 | 167 ± 0.342 | 3.42e+08 ± 6.2e+05 | 0.127 |
| 4b1j | 76.5 ± 1.5 | 26.7 ± 0.693 | 2.23e+03 ± 999 | 2.82e+03 ± 176 | 2.47e+04 ± 5.66e+03 | 3.56 ± 0.17 | 0.613 ± 0.0463 | 2.77e+03 ± 132 | 439 ± 32.8 | 165 ± 2.05 | 3.4 ± 0.0487 | 3.31e+04 ± 5.75e+03 | 0.42 |
| forward | 49.5 ± 1.2 | 1.93 ± 0.186 | 0 ± 0 | 496 ± 74 | 5.19e+03 ± 2.6e+03 | 0.235 ± 0.0436 | 0.0771 ± 0.0164 | 316 ± 44.7 | 66.2 ± 12.7 | 85.6 ± 1.48 | 0.751 ± 0.0229 | 6.16e+03 ± 2.6e+03 | 0.63 |
| MET and $\Delta\phi$ | 25.5 ± 0.864 | 1.57 ± 0.168 | 0 ± 0 | 22 ± 15.6 | 0 ± 0 | 0.194 ± 0.0397 | 0.063 ± 0.0149 | 25.3 ± 12.6 | 29.4 ± 8.5 | 66.1 ± 1.3 | 0.0565 ± 0.00628 | 145 ± 21.8 | 2.12 |
| M1M2 | 13.8 ± 0.636 | 0.162 ± 0.054 | 0 ± 0 | 0 ± 0 | 0 ± 0 | 0.0486 ± 0.0198 | 0.014 ± 0.007 | 0 ± 0 | 2.45 ± 2.45 | 5.94 ± 0.389 | 0.00488 ± 0.00185 | 8.62 ± 2.48 | 4.71 |

# Plots

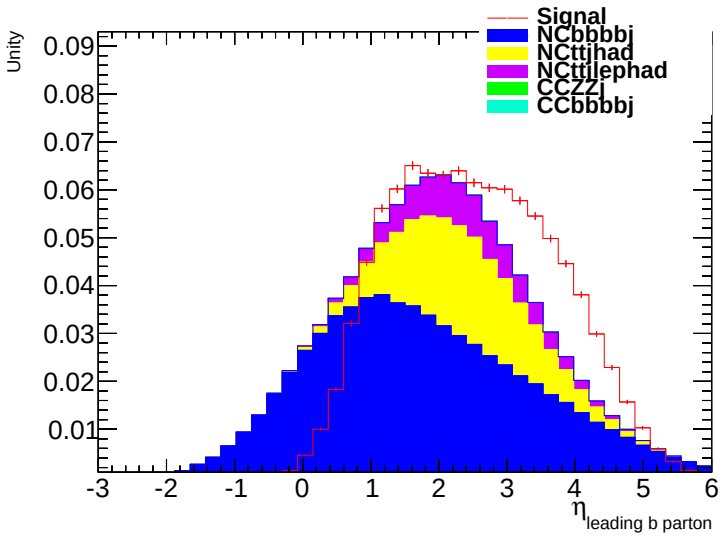

Unity
Signal
NCbbbbj
NCttjhad
NCttjlephad
CCZZj
CCbbbbj
$\eta_{\text{leading b jet}}$

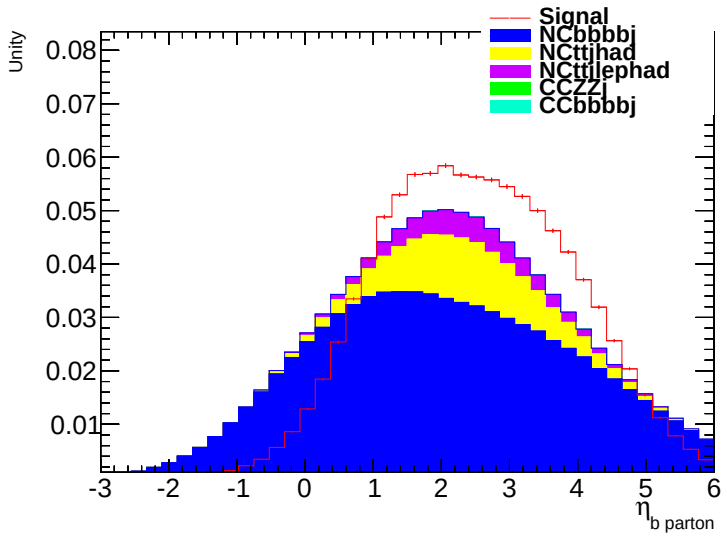

Unity
Signal
NCbbbbj
NCttjhad
NCttjlephad
CCZZj
CCbbbbj
$\eta_{\text{b jet}}$

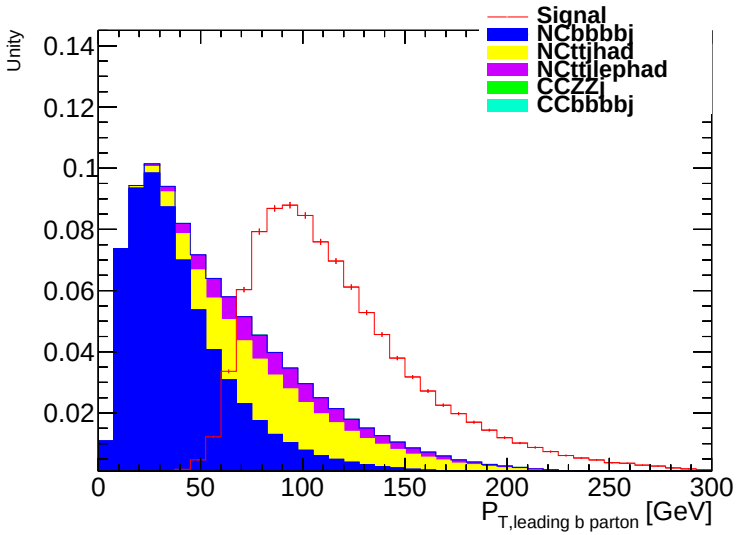

Unity
Signal
NCbbbbj
NCttjhad
NCttjlephad
CCZZj
CCbbbbj
$P_{T,\text{leading b jet}}$ [GeV]

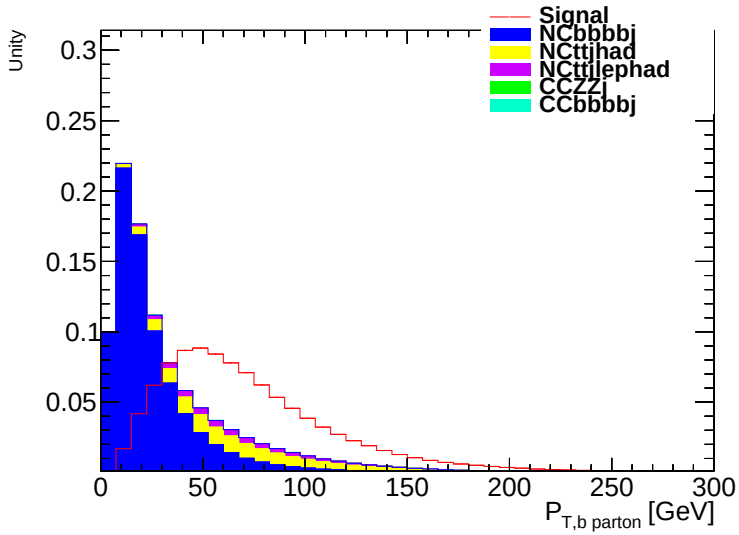

Unity
Signal
NCbbbbj
NCttjhad
NCttjlephad
CCZZj
CCbbbbj
$P_{T,\text{b jet}}$ [GeV]

# Plots

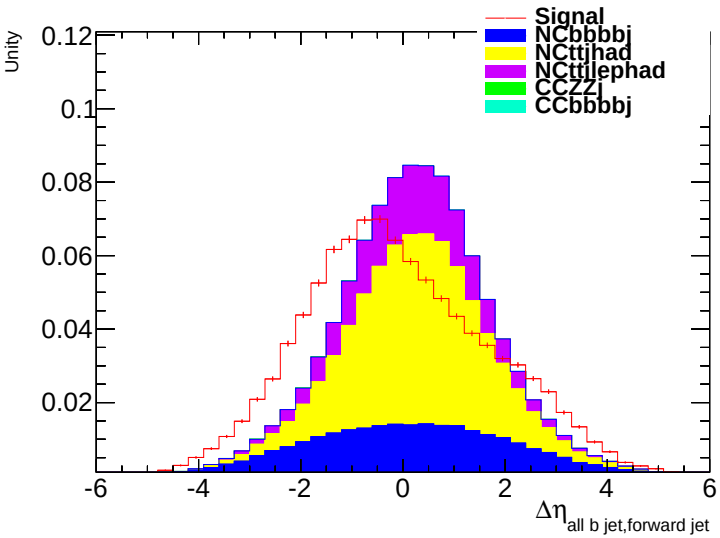

Unity
Signal
NCbbbbj
NCttjhad
NCttjlephad
CCZZj
CCbbbbj
$\eta_{\text{leading b parton}}$

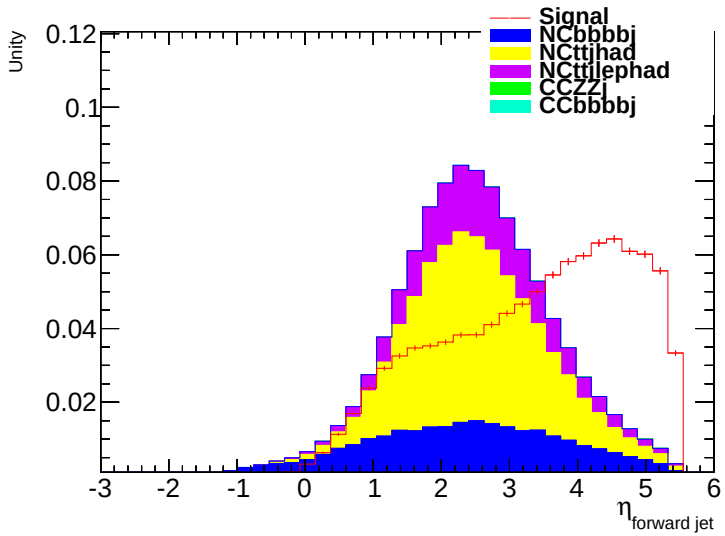

Unity
Signal
NCbbbbj
NCttjhad
NCttjlephad
CCZZj
CCbbbbj
$\eta_{\text{b parton}}$

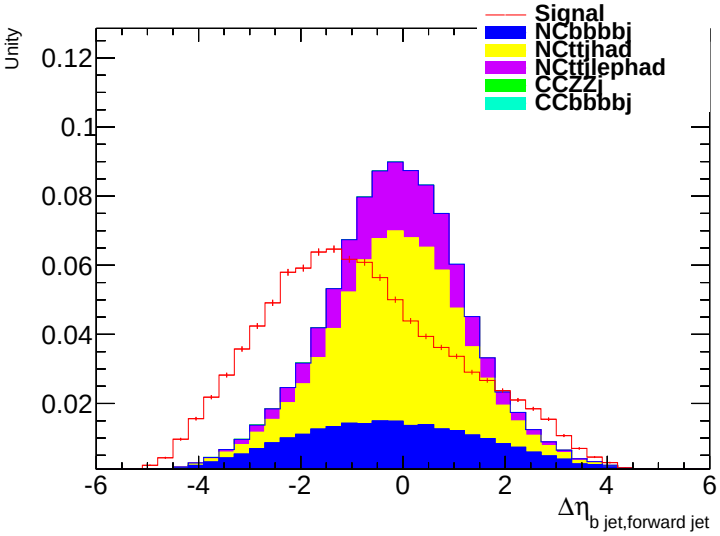

Unity
Signal
NCbbbbj
NCttjhad
NCttjlephad
CCZZj
CCbbbbj
$P_{T,\text{leading b parton}}$ [GeV]

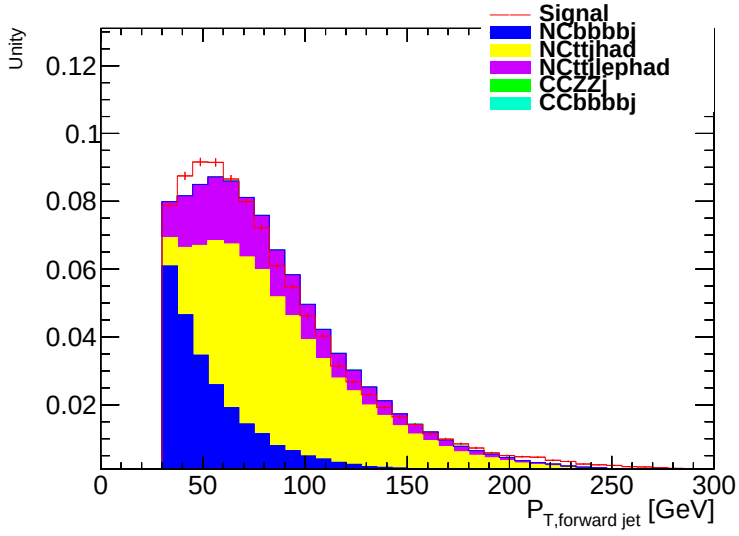

Unity
Signal
NCbbbbj
NCttjhad
NCttjlephad
CCZZj
CCbbbbj
$P_{T,\text{b parton}}$ [GeV]

# Plots

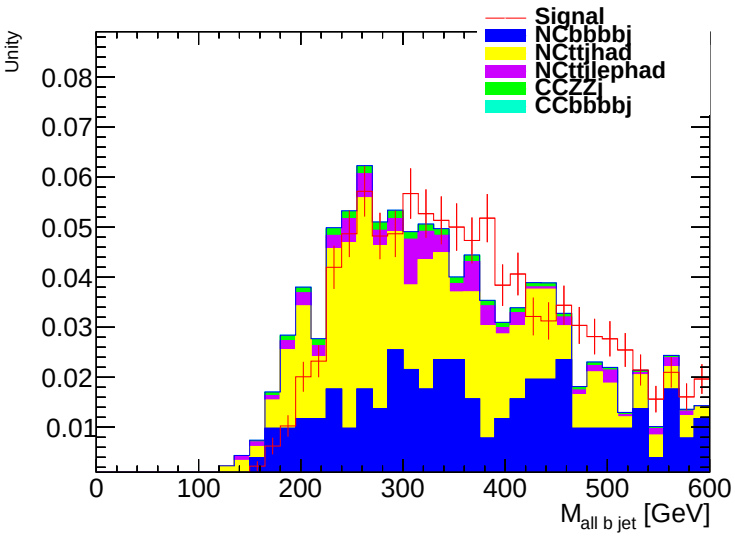

Signal
NCbbbbj
NCttjhad
NCttjlephad
CCZZj
CCbbbbj
Unity
0.12
0.1
0.08
0.06
0.04
0.02
-6
-4
-2
0
2
4
6
Δη all b jet,forward jet

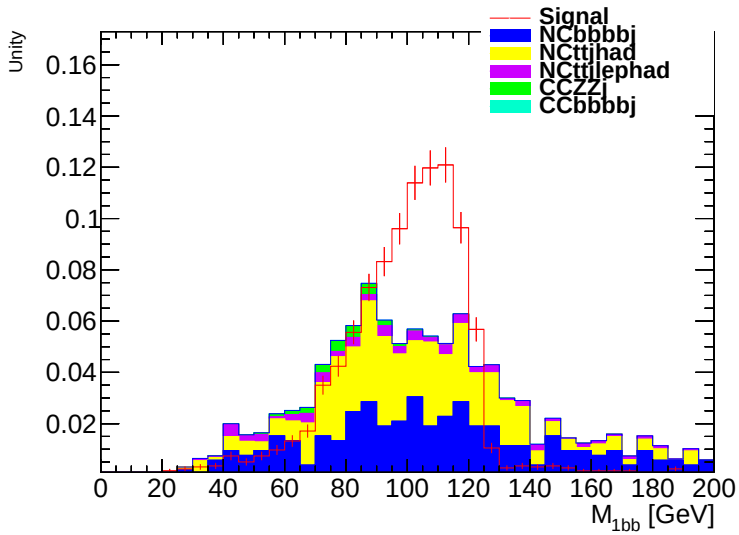

Signal
NCbbbbj
NCttjhad
NCttjlephad
CCZZj
CCbbbbj
Unity
0.12
0.1
0.08
0.06
0.04
0.02
-3
-2
-1
0
1
2
3
4
5
6
η forward jet

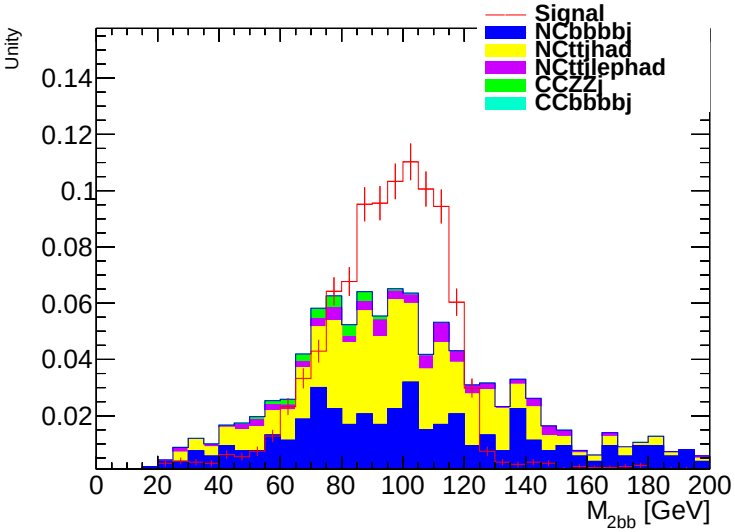

Signal
NCbbbbj
NCttjhad
NCttjlephad
CCZZj
CCbbbbj
Unity
0.12
0.1
0.08
0.06
0.04
0.02
-6
-4
-2
0
2
4
6
Δη b jet,forward jet

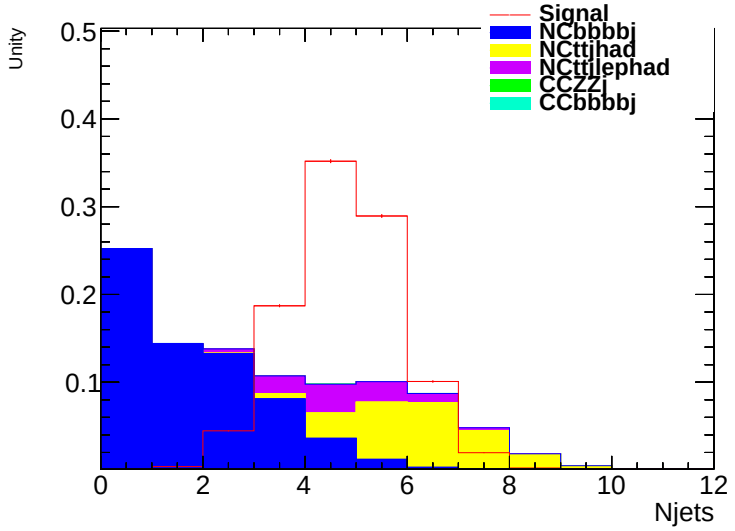

Signal
NCbbbbj
NCttjhad
NCttjlephad
CCZZj
CCbbbbj
Unity
0.12
0.1
0.08
0.06
0.04
0.02
0
50
100
150
200
250
300
P T,forward jet [GeV]

# Plots

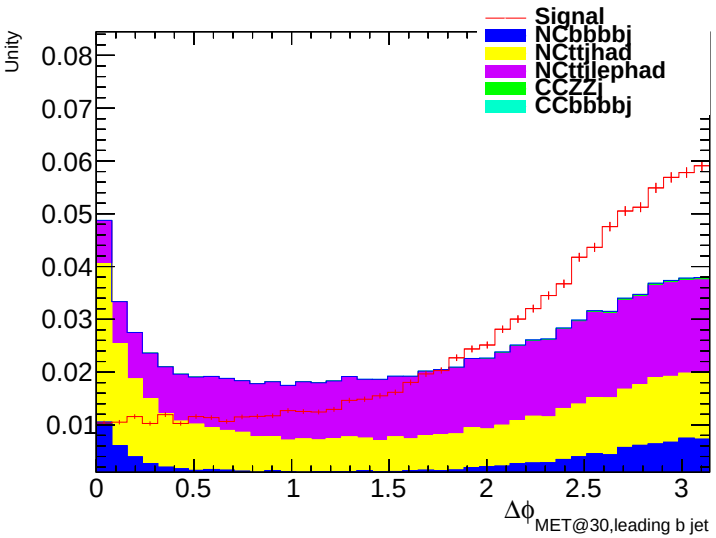

Signal
NCbbbbj
NCttjhad
NCttjlephad
CCZZj
CCbbbbj
Unity
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
100
200
300
400
500
600
M all b jet [GeV]

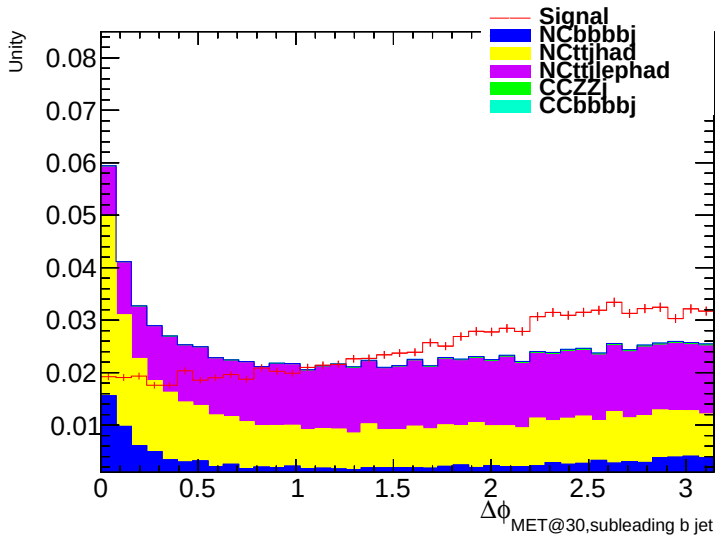

Signal
NCbbbbj
NCttjhad
NCttjlephad
CCZZj
CCbbbbj
Unity
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
20
40
60
80
100
120
140
160
180
200
M 1bb [GeV]

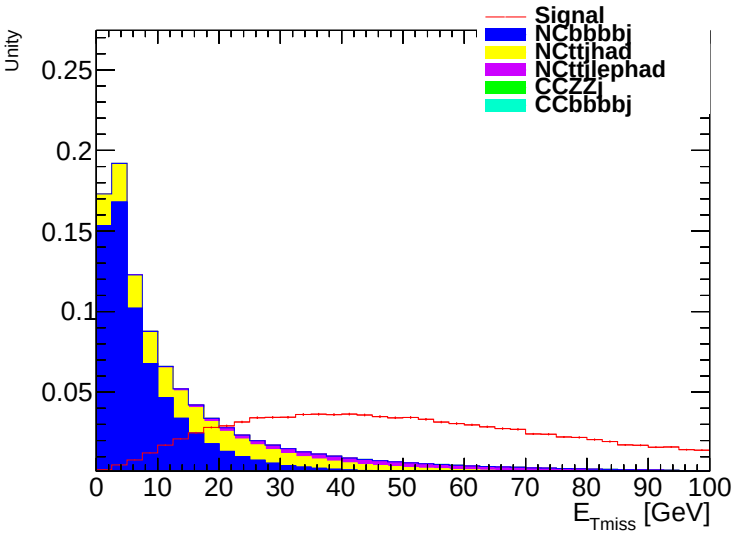

Signal
NCbbbbj
NCttjhad
NCttjlephad
CCZZj
CCbbbbj
Unity
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
20
40
60
80
100
120
140
160
180
200
M 2bb [GeV]

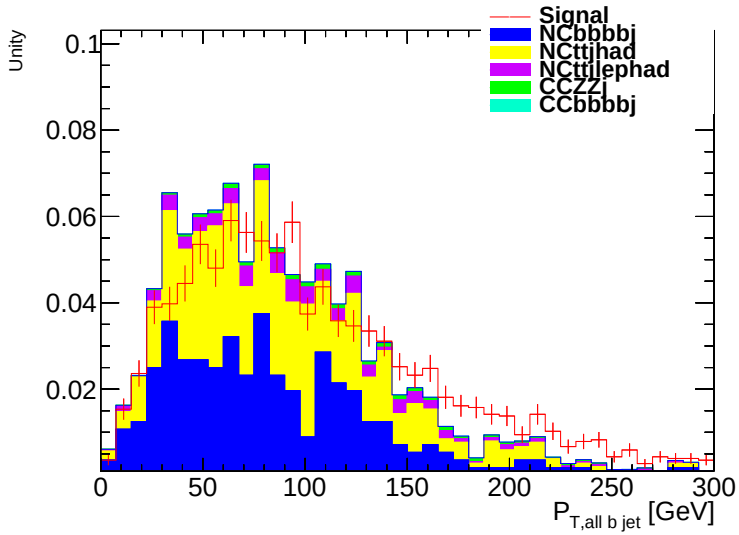

Signal
NCbbbbj
NCttjhad
NCttjlephad
CCZZj
CCbbbbj
Unity
0.5
0.4
0.3
0.2
0.1
0
2
4
6
8
10
12
Njets

# Plots


Signal
NCbbbbj
NCttjhad
NCttjlephad
CCZZj
CCbbbbj
Unity
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0.5
1
1.5
2
2.5
3
Δϕ MET@30,leading b jet


Signal
NCbbbbj
NCttjhad
NCttjlephad
CCZZj
CCbbbbj
Unity
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0.5
1
1.5
2
2.5
3
Δϕ MET@30,subleading b jet


Signal
NCbbbbj
NCttjhad
NCttjlephad
CCZZj
CCbbbbj
Unity
0.25
0.2
0.15
0.1
0.05
0
10
20
30
40
50
60
70
80
90
100
E Tmiss [GeV]


Signal
NCbbbbj
NCttjhad
NCttjlephad
CCZZj
CCbbbbj
Unity
0.1
0.08
0.06
0.04
0.02
0
50
100
150
200
250
300
P T,all b jet [GeV]